Report on the

First National Workshop

on

Acid Rain and Emissions Reduction in Asia

July 27-28 1998, New Delhi

Organised by

Tata Energy Research Institute (TERI)

Sponsored by

UNEP Environment Assessment Programme for Asia and the Pacific (UNEP EAP-AP)
and
Asian Development Bank (ADB)

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First National Workshop on

Acid Rain and Emissions Reduction in Asia

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Organized by
Tata Energy Research Institute (TERI)

July 27-28th, 1998 at India International Centre Annexe, New Delhi

Day 1 : July 27, 1998

0930	Registration
1000	Opening session Key note addresses by a) Dr E A R Ouano, ADB b) Dr G K Pandey, MoEF c) Mr P V Sridharan, TERI
1040	Tea/Coffee
1100	Acid Rain-Case study for India (Including RAINS-Asia model) (Dr T S Panwar, TERI)
1200	Deposition and dispersion aspects of RAINS-Asia (Dr Manju Mohan, IIT Delhi)
1300	Lunch
1400-1700	Brief presentation of the RAINS-Asia model followed by hands-on training (Mr Collin Green, RMA)

Day 2 : July 28, 1998

0930	Results of the BAPMoN programme (Dr B Mukhopadhyay, IMD Delhi)
1030	Tea/Coffee
1100	RAINS-Asia Model Session (continued) (Mr Collin Green, RMA)
1300	Lunch
1400	Air Pollution Issues in Asia (Mr Sunil Malla, UNEP/EAP-AP)
1500	Feedback from participants and concluding remarks : Chair- Dr EAR Ouano
1530-1630	Distribution of the RAINS and RESGEN softwares/manuals and practise session on the RAINS model continued.

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National Workshop on "Acid Rain and emissions reduction in Asia", New Delhi, July 27-28, 1998

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WORKSHOP REPORT

Ist National Workshop on "Acid Rain and emissions reduction in Asia", New Delhi, July 27-28, 1998

As part of the project "**Acid rain and emissions reduction in Asia, Phase II**", first national workshop was organised by the Tata Energy Research Institute (TERI) on July 27-28 at New Delhi. This workshop was sponsored by the UNEP Environment Assessment Programme for Asia and the Pacific (UNEP EAP-AP) and the Asian Development Bank (ADB).

The participants for the workshop were drawn from the government sector as well as researchers and experts in the field of energy and environment. A total of about 33 participants took part in the two day workshop. The objective of the workshop was to impart training to the participants on the use of the "RAINS-Asia" model and distribute the software to them. Also, a few presentations related to the theme of acid rain were scheduled.

ıgural session

The welcome address was delivered by Dr. T S Panwar, who is the National Coordinator for India for the above project. The key note addresses were delivered by Dr. E A R Ouano, Senior Environment Specialist, ADB, Dr. G K Pandey, Director, Ministry of Environment and Forests (MoEF) and Mr. P V Sridharan, Senior Fellow, TERI.

T S Panwar, TERI

Dr. Panwar welcomed all the participants and resource persons (Dr. Ouano from ADB, Mr. Malla from UNEP, and Mr. Collin Green from RMA) to the first national workshop on "Acid Rain and Emissions Reductions in Asia". The workshop was aimed to provide hands-on training on the RAINS-Asia model and to distribute the software copies for use by the participants. Subsequently after about an year, feedback would be invited from the participants on the applications of the model, its usefulness, the drawbacks noticed and their improvements / suggestions. In this regard, continued interaction with the participants was desirable.

Dr. Panwar thanked the Asian Development Bank (ADB) and UNEP Environment Assessment Programme for Asia and Pacific (UNEP EAP-AP) for the support extended for organizing this workshop. The assistance provided by Dr. Ouano and Mr. Malla was thankfully acknowledged. UNEP EAP-AP is involved in coordinating

similar workshops in China, Thailand and Indonesia as well. Mr. Collin Green from Resource Management Associates (RMA), USA, who was the resource person for providing hands-on training on the model, was also welcomed.

In addition, the Ministry of Environment and Forests (MoEF) was also thanked for approving / recommending TERI as the national coordinating agency. The contributions of the steering committee, comprising of representatives from MoEF, CPCB, IIT Delhi and TERI, were gratefully acknowledged. The steering committee assisted in the technical aspects of organizing this workshop and provided useful suggestions for workshop organization.

Dr. E A R Ouano, ADB:

Dr. Ouano started by highlighting that the policy of the World Bank as well as the ADB stressed on the assessment of not only the local environmental impacts of various projects but also the regional and possibly global impacts as well. The global environmental impacts are often on a wider scale and it is difficult presently to identify and discuss the impacts in most of the EIAs. However, in case of large power projects, it is important to look at the incremental regional impacts of power projects. For this reason, it is important to have models to address this issue in the more quantitative manner. RAINS Asia is one such model which addresses the problem of acid rain on a regional scale. A number of institutes from all over the world were involved in the development of this model. The distributed version of the model is a simplified version and the ADB is looking into the possibility of making available the detailed model with all the components so that experts in this region could analyse the model more critically. Similar acid rain workshops were held in other Asian countries as well and some of the questions raised there were that the critical load component of the model is rigid and fixed, the number of point sources are more or less fixed, and fixed costs, etc. Ultimately, the ADB viewpoint is to have more inputs and suggestions for additional improvement directly from the users. The inputs from the users could be relayed to the World Bank which is currently funding an additional modification and refinement of the model. Also, additional monitoring and verification on the east Asian side is ongoing. The ADB views that the model, which was completed in early 1996 and uses the 1990 data, has not been extensively used or evaluated by experts in different Asian countries. So, they would not like to spend more for a sophisticated model if the existing model has not been used much. Thus, they were trying to encourage different experts in the region to utilize and examine the model. Also, it was hoped that the model would be used for quantification of regional impacts due to large power / industrial projects. The participants were requested to provide their feedback on the use of the model.

Dr. G K Pandey, MoEF

Dr. G K Pandey followed up on the issue of constraints of the model mentioned by Dr. Ouano. He stressed the point that since the model uses 1990 data and we are currently in 1998, so a lot of changes have taken place, especially with respect to the energy scenario due to lot of changes in coal consumption, fuel oil and other kind of energy inputs. It was hoped that extensive monitoring and validation exercise and other improvements being contemplated would result in an improved version of the model that would be applicable to Indian conditions as well.

Dr. G K Pandey then moved on to provide an overview of the Indian scenario with respect to energy consumption and its impact on the environment and the measures taken by the government to control air pollution.

The major categories of pollution in the country could be listed as Industrial pollution, Domestic waste, Vehicular pollution, Agricultural pollution and Noise pollution. Industrial Pollution at the moment is causing a lot of problems but as far as metropolitan cities are concerned, it is the vehicular pollution which is posing a real challenge to us. Domestic (sewage) waste which is being put into our rivers and lakes and in the coastal areas accounts for 65% of water pollution problems in the country. Some of the main causes of vehicular pollution are the significant increase in the population of the vehicles especially in the metropolitan cities, two stroke engines used in two wheelers and three wheelers having high pollutant emissions, no limit to the life of vehicles, improper driving habits, etc. In respect of agricultural pollution, uncontrolled use of pesticides, insecticides and chemical fertilizers is leading to surface water, and ground water contamination. Noise pollution is basically due to traffic and industrial operations.

The Government has taken a lot of measures and a broad framework of legislation has been provided (Water Pollution Act, 1974; Air Act, 1981; Environment Protection Act, 1986; Public Liability Insurance Act; Hazardous waste rules, etc). The MoEF has brought out two basic documents known as policy statement for abatement of pollution and policy statement on environment and development in 1992. Some of the issues being addressed are prevention of pollution at the source itself, polluter pays principle, cleaner production and use of economic instruments.

Some of the other measures taken are listed as follows:

- Identification of heavily polluted areas and drawing up an action plan for implementation
- Formulation of industry specific standards
- Establishment of waste minimization circles /schemes for adoption of clean

technology, zoning atlas programme for proper citing of the industries
- Monitoring network to measure ambient air quality/ water quality
- Fiscal incentives for pollution control equipment
- Greater emphasis on public involvement

An analysis of the ambient air quality data in the 4 major metropolitan cities (Delhi, Mumbai, Calcutta and Chennai) do give a definite indication that the levels are increasing.

An interesting observation related to air pollution trend in Delhi is that while industry accounted for 56% of the pollution load in 1970-71, it is expected to come down to 20% by 2000. However, share of transport sector is expected to rise to 72% by 2000. The coal used by the power sector has lot of ash content, sometimes going even upto 45%. Thus, the government has notified that by June 2001, the power plants located more than 1000 Km from the pithead should use coal having maximum ash content of 34%.

As far as acid rain is concerned, we may not have it as a major problem in our country. This is because still out industrial production is much less in comparison to the neighbouring countries. For example, China's steel production is more than 100 million tons while in India it is only 20 million tons. Similarly, the coal consumption in China is much higher than India. In the years to come, we are not likely to see major acid rain problems. But conglomerations of power plants like Singrauli and Korba are potential areas where there may be localized problems. In any case, these are unlikely to lead to transboundary pollution problem.

Mr. P V Sridharan, TERI

Mr. Sridharan spoke about TERI's involvement in the acid rain project during the past 8-10 years and also pointed out that SO_2 problem is not a major issue in India at present.

TERI had participated in the 2nd acid rain workshop which was organized at AIT, Bangkok in 1990 and after that we were involved in collecting energy data for the ENEM module of this model. There were major constraints with respect to the data availability as well as the resources and time duration for the project, which was completed in 1994. There is a strong need for updating the data because the energy scenario has undergone lot of changes.

Currently, TERI is also involved in a related project entitled "Potential for use of renewable sources of energy in Asia and their cost effectiveness in air pollution abatement". The other collaborating institutes in this EU funded project are ERI, China, WIMEK, Netherlands, and IIASA, Austria. In addition, TERI is the national

coordinating agency for the current project entitled "Acid rain and emissions reduction in Asia, phase II" funded by the ADB and UNEP EAP-AP.

Regarding the pollution status in India, an analysis of the CPCB ambient air quality data for 1994 indicates that out of 62 cities considered, SPM levels in 48 cities exceed the CPCB standard prescribed for residential areas, while in 60 cities the values were higher than the WHO standard. This does indicate that SPM is a major problem in India. On the other hand, in the case of SO_2 only 3 stations exceed the WHO standard as well as the residential standard prescribed by CPCB.

Acid rain - case study for India : Dr. T S Panwar, TERI

The objectives of the case study were to compile information related to acid rain studies in India, and to present India specific results of the RAINS-Asia model. Initially, a brief description was provided of the acidification phenomenon, acid rain and the anthropogenic sources and effects of acid deposition. An analysis of the ambient concentration levels of precursor gases for acid rain (i.e., SO_2 and NO_x) at various stations in India was presented. Based on 1995 air quality data, critical levels of SO_2 and NO_x were found at only two cities, while a large number of cities in India had critical levels of SPM.

Rainfall data analysis revealed that the pH was in the acidic range at only a few places (Chembur in 1976, Korba in 1995, Trivandrum, etc). However, majority of the stations had pH greater than 7 and some of them had in the range of 6-7. The importance of natural dust in controlling the acidity of rain was emphasised. pH of rain water is influenced to a large extent by the pH of soil and the dust load in the surrounding region. Indian soils are normally basic in character and the dust load is quite high. Therefore, the pH of rain water is in general in the basic range. Results were also presented relating to data from the 10 background air pollution monitoring network (BAPMON) stations. The annual precipitation volume weighted mean values of pH are in the range 6.0-7.4. Except for the eastern part of the country, the other regions are dominated by alkaline scenario. The spread of acid rain in India is controlled because of low concentration of acidic components and high concentration of alkaline particulates in the atmosphere. Acid rain so far is a local phenomenon. However, its occurrence in future cannot be ruled out due to increasing pollution and higher emissions.

Case studies on acid rain for Chembur-Trombay, Korba, etc. were also presented. Subsequently, a brief description about the RAINS-Asia model was provided. India specific results obtained from the model were discussed. The energy consumption shows a 302% increase during the period 1990-2020 and the corresponding SO_2 emissions increase by 321%. During this period, while the share of coal remains roughly the same, that of oil increases from 29% to 40%. The massive increase in

SO_2 emissions lead to sulphur deposition above the critical loads of the ecosystem. Maps showing the excess sulphur deposition above critical loads for various scenarios were presented. In 1990, the excess sulphur deposition was limited only to a few locations. However, in 2020 under the reference scenario, the situation changes significantly and large regions in northern and eastern India show sulphur deposition level that exceed the critical load in those areas. The emissions and abatement costs for India under various control scenarios were presented. While the option of using best available technology has a remarkable effect on critical loads, the control costs are just as striking as the environmental improvements.

Lastly, the various uses of the model were listed and its limitations were also pointed out.

Deposition and dispersion aspects of RAINS-Asia: Dr.Manju Mohan, IIT Delhi

Dr. Mohan provided an overview of the various modules in the RAINS-Asia model and then focussed on the description of the ATMOS model. The ATMOS model is a long range transport and deposition model for sulphur in Asia. The model is a lagrangian parcel model with three vertical layers. It calculates the ambient concentration, and the wet and dry deposition of SO_2 and sulphate resulting from area and point sources. The ATMOS sub-module of RAINS-Asia model provides the link between the emissions and deposition. It provides a matrix for each 1 degree by 1 degree grid cell which includes annual deposition of sulphur and SO_2 levels as a function of SO_2 emissions.

A description of modelling framework was provided. The model formulations related to transport, chemical kinetic mechanisms, removal processes, etc were discussed. A detailed description of the ATMOS model was provided including the puff emissions, mixing layers, concentration and deposition calculations, input data, etc. Details about the model validation effort were presented. Dr. Mohan was the coordinator of the SO_2 passive sampler monitoring network in India. Results from the 10 monitoring stations were presented and comparisons were made against the model predictions. At a number of stations, the variations between observed and predicted values were quite significant.

A number of suggestions were also provided for future work. These included updating of energy-emissions data, micro-scale modelling, data analysis for diffusion parameters, zoom-in facility, further model validation, and inclusion of other pollutants like NO_x.

Results of the BAPMON programme : Dr. B Mukhopadhyay, IMD Delhi

The background air pollution monitoring network (BAPMON) has 10 stations spread all over the country where monitoring of precipitation chemistry has been going on since 1974. Graphs depicting the annual pH of rainwater for the period 1974-1990 were presented. The annual precipitation volume weighted mean (APWM) were in the range 6.1- 7.4. Time series of pH for six out of 10 stations show dipping tendencies. The post 1982 epochal mean is significantly lower. The downward tendency of pH over the years could be explained by the increase in the concentrations of strong acid radicals, primarily, nitrate. Source apportionment of precipitation composition and principal component loadings were also discussed. The relative abundance of ionic constituents in rainwater were analysed and the results indicate that with respect to sulphate and nitrate, the BAPMON are really background.

Presentation on the RAINS-Asia model: Mr. Collin Green, RMA, USA

Mr. Green from Resource Management Associates, USA gave a detailed presentation on the overall structure of the RAINS-Asia model and the interlinkages between the different sub-modules. The capabilities of the model were highlighted and key features of the modules were discussed.

The Regional Energy and Scenario Generator (RESGEN) module estimates energy consumption patterns based on socioeconomic and technological assumptions. The Energy and Emissions (ENEM) module uses these energy scenarios to calculate sulphur emissions and the costs of selected control strategies. The Deposition and Critical Loads (DEP) module, which consists of the Atmospheric Transport and Deposition (ATMOS) submodule and the Environmental Impact and Critical Loads (IMPACT) submodule, calculates the levels and patterns of sulphur deposition resulting from a given emission scenario and the ecosystem critical loads and their environmental impacts based on these patterns.

The various applications of the model were listed and results presented for different scenarios. Some of the illustrations were drawn from the Thailand case study where the model was used extensively.

Subsequently, in this session as well as on the next day, extensive hands-on training was provided to the participants on the use of the model. Mr. Green chose many examples and showed the participants how the apply the model and interpret the results. Mr. Sunil Malla too assisted the participants during the training session. The participants had a very fruitful hands-on training session and got a number of their

queries clarified. It gave them a strong background and familiarity to use the model subsequently at their work places. Copies of both the RAINS and RESGEN software and manuals were distributed amongst the participants.

Air Pollution issues in Asia : Mr. Sunil Malla, UNEP EAP-AP

Mr. Malla updated the participants about the activities of the UNEP Environment Assessment Programme for Asia and Pacific (UNEP EAP-AP). He focussed attention on the air pollution issues, in particular, on acid rain in Asia. The role played by UNEP EAP-AP under the project "Acid rain and emissions reduction in Asia, Ph. II" as the coordinating centre for organising regional seminars and assisting in the organisation of national workshops in India, China, Indonesia and Thailand was highlighted. He also updated the participants about the efforts by UNEP in promoting intergovernmental cooperation to address the increasing threat of transboundary air pollution and consequential impacts. In this regard, Male declaration on control and prevention of air pollution and its likely transboundary effects for South Asia was mentioned as a step in the right direction.

Mr. Malla also mentioned about the Newsletter being published on "Acid rain in Asia". Copies of this newsletter would be regularly mailed to the participants and it was also available at the web site.

Feedback from the Participants

Dr. E A R Ouano, who was chairing this session, mentioned that though the model in its present form might have some drawbacks, but the important thing is that the participants should use it and provide their feedback. The World Bank is already involved in updating some of the components of the model. He mentioned that while a normal project EIA just looks at the ambient concentrations, RAINS goes further by considering the deposition aspects as well. In case of India, the model has some open LPS sites and the users could easily analyse the impact of the new plants coming up there. So, the participants were encouraged to utilise the model and come up with the new ideas about its application.

Open Discussion

Mr. P.S. Acharya from the Department of Science and Technology (DST), acknowledged the RAINS model to be good tool for decision makers and planners since one could build up various scenarios and get an assessment of the future impacts. He stated that effective use of the model is important which would provide justification for its upgradation.

He mentioned that the model uses some basic data sets. The sources of these data sets

should be specified and the entire data set for India should be separately available so that one could be fully aware of what is contained in the model. Also, he wanted the RAINS software to be compatible with packages other than Foxpro. He said that only a limited validation for India seems to have been done. Thus, further validation of the model is necessary. It was also mentioned that DST is involved in developing district-wise database on natural resources. So, he enquired about the applicability of the model at the district level. Dr. Ouano clarified that the technical support team was trying to look into the possibility of applying the model to a local area (Zoom-in facility).

Dr. T.K. Bandyopadhyay from the Ministry of Environment and Forests sought more details about the background of the model development and mentioned that the success of the model was dependent on the user. He said that they would provide detailed comments only after using the model. Dr. Ouano reiterated that specifically for big projects like large power plants, a need was felt for regional impact assessment. Based on the assessment carried out, Acid Rain problem was identified as an acute one. So, besides the institutions involved in RAINS – Europe development, Asian Institutes were also invited to provide the regional inputs. Thus, a number of institutes all over the world were involved in the model development.

Mr. K.V. George from NEERI enquired about the availability of the details related to the atmospheric program. Dr. Animesh Kumar from NEERI said that based on the RAINS model, deposition of SO_2 from power plants could be included in the EIA studies. This would somewhat reduce the uncertainty of using Gaussian models.

Dr. M. Agrawal from Banaras Hindu University felt the model to be good but said that the baseline data needs to be properly analysed. Also she mentioned that the height of the monitoring stations in India was different which might lead to variations in the monitored results.

Summary

In brief, the response from the participants of the workshop could be summarised as follows:

- RAINS – Asia model is a good tool for decision makers and planners
- It is important to have access to detailed data set, sources etc. There is a need to review baseline data
- Look into the possibility to link RAINS data with database stored in other packages
- Application of model to district level / city level.
- Model validation needs greater efforts. Presently, observed and predicted values show large variations
- More details of atmospheric module required

- Detailed comments would be possible only after the participants start using the model
- Deposition of SO_2 from power plants could be included in the EIA studies to supplement results obtained from Gaussian models.

In the end, Dr. Ouano thanked all the participants for their active participation in the workshop and hoped that more viewpoints will emerge in the second workshop. He also thanked TERI for organising the workshop very well.

Lastly, Dr. Panwar too thanked all the participants and requested them to use the model and write about any problems that they might face in using it. It was mentioned that the second national workshop would be held specifically to get the feed back from the participants. The contributions of the resource persons, namely, Dr. Ouano, Mr. Malla, and Mr. Green, were gratefully acknowledged. The funding organisations i.e., ADB and UNEP / EAP – AP were thanked for the kind support provided. The MoEF was also thanked for recommending TERI as the national coordinating agency.

ANNEXURE : LECTURE MATERIAL

NATI• NAL WORKSHOP ON "ACID RAIN AND EMISSIONS REDUCTION IN ASIA", JULY 27 – 28, 1998 AT NEW DELHI

KEY NOTE ADDRESS
BY
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MINISTRY OF
ENVIRONMENT & FORESTS

The rising pollution levels in different parts of the country had caused considerable concern amongst the public at large and environmentalist in particular. However, the official concern for the environment was expressed for the first time in the Fourth Five Year Plan document stressing the need to introduce environmental dimension/consideration to the development planning process. In 1972, a Committee on Environmental Planning and Coordination (NCEPC) was constituted to advise the Government on environmental matters. In January, 1988 another Committee was set up to suggest legislative measures and administrative machinery for ensuring environmental protection. On the recommendation of this Committee, the Department of Environment was set up by the Government which was later raised to the level of the Ministry and a separate Ministry of Environment and Forests was established in 1985 to deal with environmental forestry related matters. The concern regarding environmental degradation and pollution problems was well reflected in the Parliament when a specific provision on protection and improvement of the environment and safeguarding of forests and wildlife was added to the chapter on Directive Principles of State Policy by the Constitution (Forty second amendment) Act, 1976.

Article 48 A of this Chapter states: The State shall endeavor to protect and improve the environment and to safeguard the forest and wildlife of the country.

This constitutional amendment further evidenced the concern of the Members of Parliament for environmental improvement by incorporating Part IV A on Fundamental Duties which provides for the duty of citizens to the environment. In its Article 51A the Constitution states: 'It shall be the duty of every citizen of India.... (g) to protect and

improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures'.

The Government has initiated a number of measures to protect and upgrade the environment.

2. Policy:

The Ministry of Environment and Forests is pursuing the policies enunciated in its Policy Statement for Abatement of Pollution, 1992, to deal with the environmental matters, particularly in regard to pollution of water, air and land. The Policy Statement laid the following future directions and objectives for prevention of environmental pollution:

A comprehensive approach is taken to integrate environmental and economic aspects in development planning; stress is laid on preventive aspects for pollution abatement and promotion of technological inputs to reduce industrial pollutants; and through reliance upon public cooperation in securing a clean environment to respond to the coming challenges.

The objective is to integrate environmental considerations into decision making process at all levels. To achieve this, steps have to be taken to:

- prevent pollution at source;
- encourage, develop and apply the best available practicable technical solutions;
- ensure that the polluter pays for the pollution and control arrangements;
- focus protection on heavily polluted areas and river stretches; and
- Involve the public in decision making.

3. Legal frame-work for pollution control/abatement:

The prevention & control of environmental pollution is being regulated under:

1. The Water (Prevention and Control of Pollution) Act, 1974;
2. The Air (Prevention and Control of Pollution) Act, 1981;
3. The Water (Prevention and Control of Pollution) Cess Act, 1977;
4. The Environment (Protection) Act, 1986.
5. Public Liability Insurance Act, 1991;
6. Hazardous Waste (Management and Handling Rules), 1989;
7. Environment Audit Rules, 1992.

4. Implementation Machinery:

For implementation of the Pollution Control Acts, 25 State Pollution Control Boards and 6 Pollution Control Committees in UTs were constituted under the Water (Prevention and Control of Pollution) Act, 1974. Central Pollution Control Board was also constituted under the Water (Prevention and Control of Pollution) Act, 1974. The Central Pollution Control Board was constituted by the Central Government and State Pollution Control Boards and Pollution Control Committees were constituted by the respective State Governments. The main functions of the Central Pollution Control Board are to advise the Central Government, coordinate the activities of SPCBs, provide technical assistance and guidance etc. The Government has delegated powers under Section 5 of EPA to CPCB and to the State Governments under which the regulatory agencies can take appropriate steps for prevention and control of pollution in respect of those areas which were not covered under the Water and Air Acts.

5. Promotional measures:

Pursuant to the Policy Statement for Abatement of Pollution, several initiatives have been taken for control of pollution and for promoting cleaner technologies of industrial production. These include: economic instruments, such as water cess, effluent charges, financial assistance by way of credit and loans at reduced rates of interest and subsidy, establishment of a clean technology institutional network designed to promote the development, diffusion and transfer of technologies with environmental benefits for industrial sector, extension services for the identification of appropriate waste minimisation and abatement methods for small scale industries and organization of waste minimisation circles, strengthening of standards, eco-labelling, etc.

6. Legal action against the defaulters:

A total of about 3677 cases are pending in the various courts regarding pollution, out of which about 280 cases are such in which Union of India is also one of the respondents. In all these cases, the respective State Government and the State Pollution Control Boards are the Principal Respondents. A very few number of court cases, filed in the various courts, relate to public interest litigation. Most of the cases filed by the industries in the respective States pertain to the Air and Water Acts.

The cases filed by the Pollution Control Boards are generally against industries flouting pollution control laws, violations of consent conditions, non-payment of water cess etc. Public interest Litigation are directed against industries or a group of industries causing damage to the ecology and environment. Such litigations have resulted in the closure of a number of industries in the various parts in the country.

The important cases pertaining to the public interest litigations in the Supreme Court/High Courts are given below:-

1. Bichhari case in Rajasthan;
2. Shifting/closure of hazardous units in Delhi including units located in non-conforming areas. Hot mix plants were closed as per the order of the Court;
3. Protection of Taj Mahal;
4. Closure of tannery units in Tamil Nadu and West Bengal;
5. Closure of industrial units (Dyes and Dye stuffs, Chemical units etc. in Gujarat.

7. STATUS OF AIR POLLUTION IN THE COUNTRY

A total of 290 air quality monitoring stations have been setup which are Measuring the ambient levels of Sulphur dioxide, oxides of Nitrogen and particulate matters. The ambient air quality data has indicated an increasing trend specialy in the urban areas. The ambient air quality levels as recorded in the major cities are given in the following table:

Table-1

AMBIENT AIR QUALITY IN MAJOR CITIES OF INDIA

(in microgram per normal cubic metre)

DELHI (CPCB) R = ASHOK VIHAR, C = NIZAMUDDIN, I = SHAHDARA

YEAR	SPM			SO2			Nox		
	R	C	I	R	C	I	R	C	I
1990	000	294	314	6.6	7.4	25.3	25.4	15.7	23.3
1991	259	296	325	16.5	12.9	17.3	31.3	25.2	24.6
1992	321	358	364	17.6	16.9	16.6	32.8	30.1	34.9
1993	322	362	383	17.7	13.7	22.4	31.0	30.1	35.1
1994	310	443	350	21.1	16.1	21.3	30.0	37.2	29.0
1995	106	398	437	17.7	16.9	22.2	28.5	37.0	27.6
1996	361	443	446	16.2	17.8	19.9	25.6	36.4	28.4
1997	331	882	325	14.1	17.7	15.9	22.9	37.4	29.3
1998	231	272	305	15.2	17.4	18.6	22.1	37.3	37.5

MUMBAI **R= BANDRA, C= KALBADEVI, I= PAREL**

YEAR	SPM			SO2			Nox		
	R	C	I	R	C	I	R	C	I
1991	298	237	199	21.6	21.1	30.4	20.4	27.2	30.9
1992	312	254	150	17.5	14.3	23.4	28.4	27.1	32.4
1993	175	288	227	49.5	12.9	31.5	32.8	33.1	32.9
1994	203	215	276	37.6	24.4	42.2	21.0	32.4	51.5
1995	238	228	271	25.4	26.3	41.8	22.6	40.2	36.1
1996	196	195	247	13.8	17.7	24.6	20.3	54.1	32.5
1997	344	312	242	21.7	17.5	36	30.7	36.4	35.9
1998	257	362	284	30.4	39.9	32.5	22.1	50	33.7

CALCUTTA **R=PURUSWAKKAM, C=PARRY'S CORNER, I=THIRUVOTTIY**

YEAR	SPM			SO2			Nox		
	R	C	I	R	C	I	R	C	I
1990	186	274	302	19.5	38.5	32.5	18.0	42.0	26.0
1991	313	364	496	48.5	67.6	73.7	28.7	53.8	39.8
1992	253	355	348	22.8	38.7	47.2	17.4	33.3	32.7
1993	235	507	640	16.8	65.1	38.8	18.1	62.0	40.2
1994	279	372	476	29.9	57.3	58.7	21.2	45.5	35.7
1995	259	357	447	42.6	47.1	47.4	16.2	38.3	35.2
1996	110	271	-	10.4	48.6	80.0	10.0	70.7	30.8
1997	210	272	367	11.1	37.8	33.0	16.8	44.0	33.3
1998	460	570	835	12.1	53.4	46.7	37.6	64.7	67.7

CHENNAI **R= SATHOME, C= CENTRAL HOSP, I= THIRUVOTTIYUR**

YEAR	SPM			SO2			Nox			
	R	C	I	R	C	I	R	C	I	
1990	78	98	NA	8.7	10.7	NA	11.7	18.0	NA	
1991	85	86	142	6.7	8.2	10.2	8.3	18.0	18.9	
1992	77	92	53	6.8	7.8	9.6	8.2	15.4	13.0	
1993	74	73	97	6.9	10.8	10.3	9.1	27.1	13.2	
1994	94	115	146	6.8	8.6	9.6	9.5	21.0	13.7	
1995	95	117	NA	6.8	8.8	NA	8.9	20.1	NA	
1996	67	100	99	7.0	8.5	8.2	7.0	12.8	10.0	
1997	89	105	118	7.4	9.0	9.7	10.0	13.0	9.2	
1998	60	156	85	9.2	10	11	8.1	16.9	6.8	

8. COAL PRODUCTION AND CONSUMPTION SCENARIO

Coal production registered an annual growth rate of 6% steadily increasing from a level of 77 million tonnes in 1972 – 73 to about 246 million tonne 1993 – 94.

Electricity sector is the single largest consumer of coal consuming about 66%, followed by steel sector 13% and cement industry 5% of coal consumed during 1992-93. Balance 16% was consumed by thousands of other industries.

The coal based electricity generation at the time of nationalisation of the coal industry in 1973was around 8000 Mw. This has steeply increased to a level of 54,000 MW, which is 67.5% of the total installed capacity as of now. The coal based installed capacity is projected to further go beyond 80,000 MW projected for the year 2020. The electricity sector will, therefore, remain the largest coal consumer in future also.

Electricity sector's requirement of coal with reference to distances from the coal-fields has been projected as follows:

Table-2
Coal Consumption by Power Plants
(in million tonnes)

Distance	1992 – 93	1996 – 97	2001 – 02	2009 – 10
Pit-head	55.37	84.13	98.10	106.00
500 km	35.28	39.08	45.45	47.90
500 – 1000 km	20.35	22.44	26.70	40.00
1000 km	38.53	44.35	70.75	146.10
	149.43	**190.00**	**241.00**	**340.00**

9. POWER GENERATION SCENARIO

At present, a total of about 89097.98 MW power is generated, the break up of which is given below:

Thermal	64995.78 MW
Hydel	21899.08 MW
Nuclear	2225.00 MW
Wind	968.12 MW
	89097.98 MW

10. AIR POLLUTION TREND IN DELHI

It is interesting to note from the following table that in the year 1970-71, the contribution of air pollution was 56% and that of vehicular pollution was 23%. It has been estimated that in the year 2000-01, the contribution of pollution from industry will come down to 20% and in case of vehicular pollution it would go up to 72%. Similar situations are likely to be for other mega cities (population more than 40 lakhs) such as Mumbai, Chennai, Calcutta, Hyderabad and Bangalore.

Table-3
Air Pollution Trend in Delhi

Source	1970 – 71	1980 – 81	1990 – 91	2000 – 2001
Industrial	56%	40%	29%	20%
Vehicular	**23%**	**42%**	**64%.**	**72%**
Domestic	21%	18%	7%	8%

11. MITIGATIVE MEASURES TAKEN FOR PREVENTION AND CONTROL OF POLLUTION

- Steps have been taken to control pollution from 17 categories of highly polluting industries. Out of a total of 1551 industries identified in 1991, now only 155 units are not having adequate facilities to comply with the standards.
- 24 critically polluted areas have been identified and Action Plans prepared for 22 areas and are being implemented by CPCB/SPCBS.
- River basin-wise surveys conducted to identify the polluted stretches and their sources. 14 major rivers are included under River Action Programme.
- Environmental guidelines for siting and operation of industries were brought out.
- Environmental clearance made compulsory for 29 categories of developmental projects involving public hearing/NGO participation as an important component of EIA process.
- Environmental audit in the form of environmental statement has been made mandatory for all the polluting industries.
- To promote pollution prevention in small scale industries, 15 waste minimization circles have been set up in various parts of the country and about 100 such more circles are being established for adoption of clean technology, better work practices and energy conservation techniques.

- Environmental Epidemiological Studies have been initiated in the different parts of the country to find out impact of pollution on human health and suggest mitigative measures.

- For control of pollution from automobiles, stricter emission standards, introduction of unleaded petrol in major cities, installation of catalytic converters, introduction of low sulfur fuels and improvement in the fuel quality have been undertaken.

- Preparation of Zoning Atlas for siting of industries based on environmental considerations in various districts of the country has been taken up. So far, 19 such districts have been covered.

- A Scheme for setting up of Common Effluent Treatment Plants (CETP) in cluster of small scale industrial units has been taken up. About 77 CETP projects have been approved which are at various stages of implementation.

- A Network of Ambient Air (290) and Water (480) Quality Monitoring Stations has been set up throughout the country.

- Effluent and Emission Standards have been notified under the Environment (Protection) Act for about 80 categories of industries. Besides, standards for ambient air and water quality have also been notified.

- A White Paper on status of pollution in Delhi with an Action Plan for its control has been prepared for Delhi and the same is being implemented. The respective State Govts. Of Maharashtra, Tamil Nadu & West Bengal have been recently advised to prepare Action Plans for Mumbai, Chennai & Calcutta respectively.

- 6 Environment Authorities have been constituted under the EPA, including the National Environment Appellate Authority.

12. CONCLUSION:

The air pollution levels have indicated an increasing trend in urban areas mainly due to rise in vehicular population, indiscriminate industrialisation and urbanisation. However, the problem of Acid rain has not yet been experienced in India. There is need to integrate population, environment and natural resource policies into national development process so as to ensure environmentally sound and sustainable development to improve the quality of life. The Government are fully seized of the problem and have taken a number of steps to mitigate pollution problems. An Action Plan for Delhi has already been prepared and is under implementation. Similar Action Plans have been proposed to be prepared soon for Chennai, Calcutta and Mumbai. A National Action Plan for Control of Pollution in the country has also been prepared and is likely to be finalised shortly.

Acid Rain - case study for India
(Including RAINS-Asia model)

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As part of the project
`Acid Rain and emissions reduction in Asia, Phase II',
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Acid Rain - case study for India (Including RAINS-Asia model)

What is Acid Rain ?

Acid Rain is one of the important environmental issues of the day. Vast areas of the northern hemisphere including central Europe, Scandinavia, north-east United States, and Canada are affected by acid rain (Bubenick, 1984). Now, it is spreading to the developing countries of the world as well. There is a great concern regarding its adverse environmental impacts.

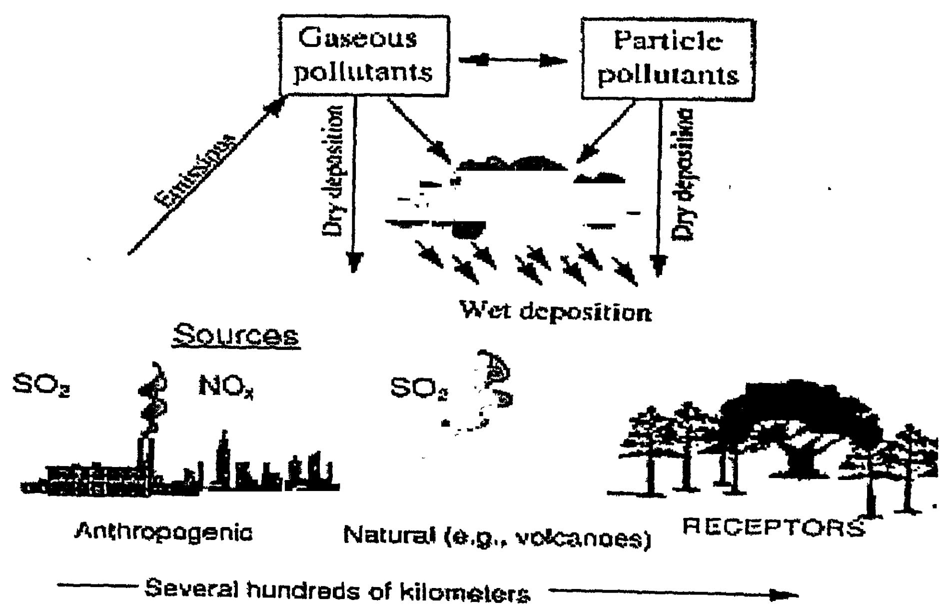
The free acidity of solution such as rain is determined by the concentration of hydrogen (H^+) ions present. It is commonly expressed in terms of pH scale where pH is defined as the negative logarithm of the hydrogen ion concentration. The pH scale extends from 0 to 14, with a value of 7 representing a neutral solution. Values less than 7 indicate acidic solutions. Pure water has a pH of 7 which is neutral. Natural, unpolluted rain water is frequently assumed to be slightly acidic with pH of 5.65. This is the pH of distilled water in equilibrium with atmospheric carbon dioxide, as determined under laboratory conditions. Many researchers have accepted this assumption and refer to rain water having a pH of less than 5.65 as acidic. Hence, the term acid rain has come to mean rainfall with pH of less than 5.65.

Contamination in the atmosphere can shift the pH of rain water either way. Alkaline soil particles containing carbonates can increase the pH. In contrast, the presence of acidic particles of sulphuric or nitric acid would decrease the pH. The processes affecting the acidity of rain water are many and very complex. These include gas-to-particle transformations, photochemistry and catalytic chemistry, aqueous chemistry within cloud drops, precipitation, regional and global integrated atmospheric transports (Khemani, 1993). The pH of precipitation is an integrated measure of the relative contributions of all of these complicated processes.

The acidification phenomenon

Acid rain is the product of chemical reactions between airborne pollutants (sulphur and nitrogen compounds) and atmospheric water and oxygen. Once in the atmosphere, sulphur dioxide (SO_2) and nitrogen oxides (NO_x) react with other chemicals to form sulphuric and nitric acids. These substances can stay in the atmosphere for several days and travel hundreds or thousands of kilometers before falling back to the earth's surface as acid rain. This process is more accurately termed "*acid deposition* " because acidity can travel to the earth's surface in many forms: rain, snow, fog, dew, particles (dry deposition), or aerosol gases (Downing et. al., 1997). A simplified overview of the process is shown in Figure 1.

Figure 1. Processes Involved in Acid Deposition



Source: Downing *et.al.*, 1997

Although sulphur and nitrogen compounds can be generated by biological processes such as natural soil decomposition or other natural sources such as volcanoes, most sulphur emitted into the atmosphere results from anthropogenic (of human origin) activities. Coal- and oil-fired power-generating stations, domestic heating, biomass burning, various industrial processes, and transportation are all important sources of emissions that cause acid deposition.

The documented effects of air pollution and acid deposition include the following :

* Major contributions to forest decline, possibly in complex interactions with natural stresses
* Release of toxic metals such as aluminum that can damage soils, vegetation, and surface waters
* Direct damage to crops and vegetation by high air concentrations of pollutants or indirect damage through chemical changes in the soil
* Damage to aquatic resources and their ecosystems
* Increased rate of erosion of monuments, buildings, and other cultural and commercial resources
* Direct, adverse effects on human health, especially for sensitive populations with respiratory or cardiovascular problems.

Emissions from large point sources of sulphur emissions such as power plants were once considered a local problem. As awareness of the harmful effects of these pollutants grew, however, new facilities were built with taller smokestacks,

designed to spread the pollution over a larger area. This wide dispersion makes the long-range acidification problem and its possible solutions a national and regional concern.

Acid Rain in India

Air pollution - levels of precursor gases (SO_2 and NO_x)

The principal precursors of acid rain are emissions of SO_2 and NO_x, whose main anthropogenic sources are activities like industries and vehicular traffic. As urban areas are the main centres of such activities, the levels of SO_2, NO_x and SPM at these locations will indicate how far they are affected by pollution sources.

The Central Pollution Control Board (CPCB) has established a National Ambient Air Quality Monitoring network (NAAQM), which has a sanctioned strength of 290 monitoring stations covering 92 cities/towns. Based on the analysis of the ambient air quality data for 1995, critical levels of SO_2 were observed in the cities of Surat and Howrah, NO_2 in Delhi and Howrah and suspended particulate matter (SPM) in almost all the cities of Bihar, Gujarat, Himachal Pradesh, Madhya Pradesh, Rajasthan, West Bengal, Delhi, and UT of Pondicherry (CPCB, 1997). The representation of air quality data has been in terms of low, moderate, high and critical based on the notified ambient air quality standards (S) for different pollutants and area classes. The air quality is termed low (L) if the value of the pollutant is less than half of the notified standards, moderate (M) if it lies between half of S and S, high (H) if it lies between S and 1.5 times S and critical (C) if it is more than 1.5 times S. Table 1 indicates the cities/towns in which the ambient air quality during 1995 in terms of SO_2 and NO_2 concentration was in the categories M, H or C. It clearly indicates that though the number of cities falling under the category C are only a few, however, there are a significant number of cities in the categories M or H.

Figure 2 represents the distribution of monitoring stations according to the annual mean concentration of SO_2 during 1995. The annual mean concentration of SO_2 violated the annual standards at 3 industrial, 8 residential and 1 sensitive location. At all other locations, the annual mean concentration conformed to the respective standards. Likewise, figure 3 represents the distribution of monitoring locations according to the annual mean concentration of NO_2. During 1995, the annual mean standards were violated at 2 industrial, 9 residential and 1 sensitive location. It may be noted that the annual average ambient air quality standards for both SO_2 and NO_2 are 15, 60 and 80 $\mu g/m^3$ for sensitive, residential/rural, and industrial area categories, respectively.

Table 1. Ambient air quality status during 1995 based on annual average in some cities/towns

State/city	Sulphur dioxide		Nitrogen dioxide	
Area/Class	Industrial	Residential	Industrial	Residential
Andhra Pradesh				
Hyderabad				M
Vishakhapatnam				M
Assam				
Guwahati				M
Bihar				
Dhanbad		M		M
Jharia	M		M	
Sindri			M	
Delhi		M	M	C
Gujarat				
Ahmedabad		H		
Ankleshwar	H	H		
Vapi		M	M	
Baroda	M	H		
Surat	H	C		
Haryana				
Faridabad		M		
Kerala				
Kottayam			M	
Maharashtra				
Bombay	M			M
Madhya Pradesh				
Bhilai				M
Jabalpur				H
Nagda	M	M		M
Rajasthan				
Alwar			M	H
Jaipur				M
Kota			M	H
Jodhpur	M	M		M
Udaipur				M
Uttar Pradesh				
Anpara	M		M	
Lucknow		M		
West Bengal				
Calcutta	M	M		M
Haldia			M	
Howrah		C	C	C
Pondicherry	H	M	H	H

Source: CPCB, 1997

M: Medium air quality; H: High air quality; C: Critical air quality

Figure 2. Distribution of monitoring locations as Per annual mean concentration of Sulphur dioxide

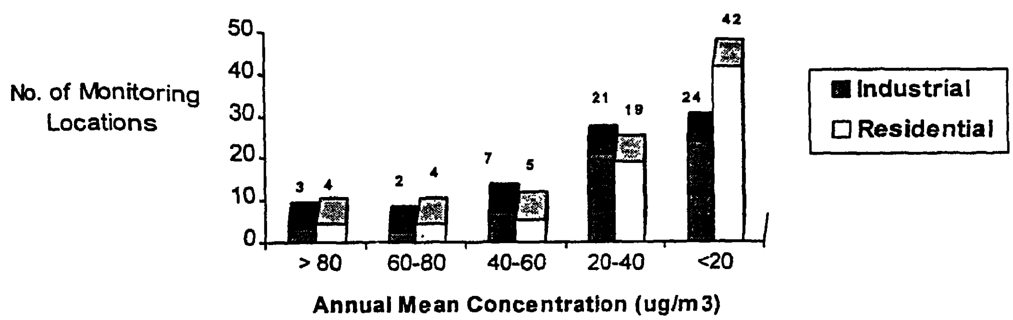
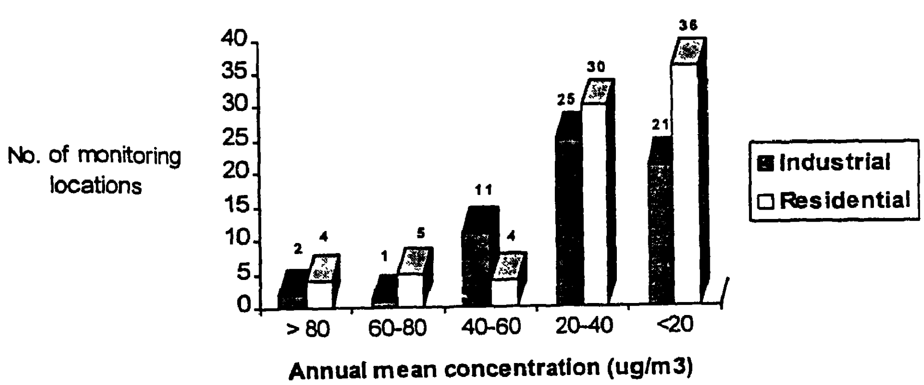


Figure 3. Distribution of monitoring locations as per annual mean concentration of Nitrogen dioxide



Rainfall data analysis

Khemani (1993) has analysed the average concentration of major ionic components along with pH values in precipitation (rain, cloud, fog and snow water) collected at different locations in India. Table 2 below lists the pH values in precipitation collected at different stations in India.

Table 2. Average pH values in precipitation collected at different stations in India

Station	pH
Rain water	
Coastal	
Trivandrum	5.30
Industrial	
Kalyan	5.70
*Chembur	4.80
Power plant	
Indraprastha	5.0
Koradi	6.70
Urban	
Pune	6.30
Delhi	6.10
Non-urban	
Sirur	6.70
Muktsar	7.30
Goraur	5.30
Forest region	
Masingudi	6.04
Cloud water	
Pune	6.90
Fog water	
Delhi	6.91
Snow water	
Gulmarg	6.68

(Source: Khemani, 1993); * Sequeira (1976)

According to this study, except at Chembur, a highly industrialized area in Bombay region, the pH of rain, cloud, fog and snow waters is alkaline at most of the other locations in India. Also, the pH of rain water at Trivandrum and Goraur (near Patna) is near the CO_2 equilibrated value. At these two places, not only the observed concentrations of SO_4^{-2} and NO_3^- are quite low, but the concentration of Ca is also quite low compared to other locations in India. It is presumed that the lower pH at Trivandrum and Goraur is not due to pollution sources but may be due to naturally produced organic acids like formic acid and acetic acid which are able to bring down the pH from 5.65 to around 5.30. (Khemani, 1993). At Indraprastha Power Plant, the pH is in acidic range (pH 5.0).

The first acid rain in India was reported from Chembur, where average pH of rain was 4.8 in 1976. Results of chemical analysis of acid rain in Chembur-Trombay area conducted during the monsoon period of 1990 have indicated that the rain in this area has become alkaline and the pH varied between 6 and 7.

The pH of rain water at other locations in India during various monsoon periods (1970-90) reported by various investigators have also been analysed by Khemani (1993). The pH values are high (pH > 7.0) at Srinagar, Allahabad, Jodhpur, Muktsar, Amritsar, Bikaner, Jaisalmer, Lucknow and Ahmedabad. The values are comparatively low but still in alkaline range (pH =6-7) in industrial towns and cities, namely, Nagpur, Vishakhapatnam, Delhi, Agra, Bhopal, Calcutta and Chandigarh. At Trivandrum and Goraur, pH is still lower (pH = 5.3).

mportance of natural dust in controlling the acidity of rain

Precipitation acidity is a function of its contents of both acids and bases, and any attempt to understand the processes causing acid precipitation must deal with the potential acid neutralizing capacity of alkaline materials. The major cations in precipitation associated with alkaline compounds (other than ammonia) are Ca, K, Mg and Na which are mostly released from crustal sources.

A study of the pH data of rainwater samples and of soils in India has been conducted by Krishna (1986) to assess the importance of natural dust in controlling the acidity of rain. It has been found that pH of rainwater is influenced to a large extent on the pH of soil and the dust load in the surrounding region. Indian soils are normally basic in character (pH in basic range) and the dust load is quite high, as such, pH values of rain are in general in basic range. It is well known that the dust load in the atmosphere over north-west parts of India is high and a significant amount of dust is incorporated into rainfall either as condensation nuclei or by collision with falling rain drops. However, the extent to which airborne dust influences the precipitation chemistry of certain geographic regions varies with its composition and abundance (Khemani et. al., 1989). Neutralizing effect of airborne dusthas been attributed as one of the reasons for higher pH values (pH > 5.6).

Further, the effect of acid rain over India (on lakes and soil), in general, may not be pronounced due to high values of cation exchange capacity soils and pH of surface water (Krishna, 1986).

Characteristics of Indian soils

The National Bureau of Soil Survey and Land Use Planning (ICAR 1982) has published Bench Mark Soils of India. pH values of soils give an idea about the chemical balance between cations and anions in the soil and it is expected that rainwater pH would be influenced to a large extent on the pH of local soil.

It is noted that the pH values of soils are quite high between 15°N and 35°N. However, the values are significantly low in the longitude belt of 85°E to 95°E

covering the northeast region of the country. High pH values (pH=6.5-10.5) of soil have been observed in Jammu & Kashmir, Punjab, Haryana, Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and some parts of Tamil Nadu. Quite low values of pH (pH = 4.8-5.3) of soil are observed in coastal Kerala and also at hill station in Tamil Nadu (Kodaikanal). In Bihar and West Bengal, broadly, pH is low (pH = 4.8-6.0). East of the above two states, pH is quite low (pH = 4.0-5.3). Broadly, it can be inferred that western parts of the country are having basic soils whereas soils in eastern part have lower pH. It is important to mention here that natural dust load in the atmosphere over northwestern parts of India is high in comparison to eastern locations. It has been also observed that at the hill stations or locations where rainfall is high, pH of soils are low due to the leaching effect. At such locations mainly laterite soils occur (Krishna, 1986).

Effects of acid rain on water bodies

Recent studies on the problem of acidification of lakes indicate that soils and bedrock play a very important role in controlling the acidity. Studies show that for rain of pH=4.0, pH of different lakes may vary between 4.8 and 7.0 due to the buffering action of different types of soils and bedrock. Limestone and sandstone, rich in calcium carbonate are potent neutralizers of acid whereas impervious granites are poor bufferer. In fact, the alkalinity of surface water which is an important parameter controlling the acidity of lakes (from acid rain) depends on the weathering of base cations from the watershed and can be used as an indicator regarding the susceptibility of lake or stream to acidification.

The limited cation exchange capacity data of soils and pH of surface waters which are available from India indicate that the Indian soils and surface waters in most of the regions may not be very sensitive from acidification point of view. However, for detailed classification regarding sensitivity of soil and lakes from acidification point of view it would be essential to have additional information on the chemical characteristics of Indian soils such as exchangeable bases and percentage of carbonates as well as the chemistry of lake waters (Krishna Nand, 1986).

Trends in background air pollution parameters (with reference to pH of rainwater)

The Background Air Pollution Monitoring Network (BAPMoN) data from ten stations in India for the period 1974-90 was analysed by Datar *et. al.* (1996) to determine the background trends. The annual precipitation volume weighted mean (APWM) values of pH were calculated and are given in Table 3. It may be noted that background pH of rain over India lies in the range 5.97-7.42. These values are higher than 5.65 for unpolluted rain. The time series of pH for six out of 10 stations i.e., Allahabad, Kodaikanal, Mohanbari, Port Blair, Nagpur, Pune and Visakhapatnam show dipping tendencies, which at Visakhapatnam is quite

pronounced. The post 1982 epochal mean is significantly lower. A possible explanation for the downward tendency of pH is the increase, over the years, in the concentrations of strong acid radicals (primarily NO_3^-).

Table 3. Mean pH of rainwater in Indian BAPMoN stations (1974-1990)

Stations	Observed pH
Allahabad	6.93
Jodhpur	7.42
Kodaikanal	6.28
Minicoy	6.58
Mohanban	5.98
Nagpur	5.97
Port Blair	6.15
Pune	6.43
Srinagar	7.22
Visakhapatnam	6.01

Source: Datar *et.al.*, 1996

Stations like Allahabad, Jodhpur and Srinagar are situated in the midst of the continent. Atmospheric dust is rich in alkaline mineral salts (bicarbonates of calcium and magnesium) and clay minerals (exchangeable cations). Thus the rainwater is highly buffered against acid radicals, which however seem to make their presence felt in recent years, whenever the atmospheric dust gets reduced.

The soils of Mohanbari are known to be heavily leached and are slightly acidic and help to keep the overall pH relatively lower. Visakhapatnam and Pune are affected to a greater extent by industries and growing urbanization. A negative correlation of pH with NO_3, which is the general feature of the Indian BAPMoN (Mukhopadhyay *et al.*1992) indicates that rapidly increasing vehicular traffic could be the primary cause for declining tendencies of the pH.

In summary, it could be stated from the BAPMoN data that except for the eastern parts of the country (i.e. Mohanbari, Port Blair), the other regions are dominated by the alkaline scenario, by virtue of crustal aerosols. The eastern soils are formed in humid climates and are leached to the extent of being slightly acidic. These are the regions susceptible to acidification of rainwater on a regional scale. In other regions, the problem of acid precipitation can at worst become an immediate (50 to 80 km) downwind problem. (Datar *et. al.*, 1996).

Conclusions

The neutralizing effect of airborne dust on rainfall acidity is now well documented. The alkaline properties of soil particulates have so far sustained the alkaline nature of rain water (pH > 5.65) and have been controlling the spread of acid rain in India. This has been possible due to low concentrations of acidic components and high concentrations of alkaline particulates in the atmosphere. Also acid rain, wherever it has occurred in India is purely a local phenomenon

and is restricted within short distances in the upwind and/or downwind of the industrial complexes. Long-range transport of acidic pollutants is the main cause of acid rain in the western countries. However, this process of long range transport of pollutants (SO_4 and NO_3) does not seem to be effective in India during the south-west monsoon period when the meteorological factors are favourable for quick dispersal of pollutants whose sources are weak. Some parts of north-east and south-west are classified as potentially sensitive to acidification due to low levels of alkaline particulate (Khemani, 1993).

Although there is no problem of acid rain at present in India, its occurrence in future cannot be ruled out as air pollution is already severe in metropolitan industrial cities. The scenario may change in the coming decades when the pressure on atmospheric environment will increase due to population growth, changing agricultural practices, increasing number of vehicles, power generation and industrial development. The Rains Asia Model results too indicate that acid rain would affect large regions in India by the year 2020 unless control measures are taken.

Brief description of some case studies related to acid rain in India

Agra case study (Saxena *et.al.*, 1996)

In the present study, the precipitation at Agra city was studied during July-September, 1991. 32 samples were collected at Dayalbagh which is a suburban area in the NW of the city with no major industrial activities and minimum traffic density. The study comprised the determination of F, Cl, NO_3, SO_4, Na, K, Ca, Mg, NH_4, Fe, Cu, Zn and SiO_2 in the wet-only samples. On the basis of the neutralizing factors and correlations, it has been determined that acid neutralization is brought about by calcium rather than the ammonium ion.

The minimum recorded pH value was 6.1 and the maximum 7.3, while the volume-weighted mean pH was 6.9 all indicating an alkaline nature as compared to the reference level of 5.65. From the data, the average relative magnitude of ionic species concentration in precipitation follows the order Ca>HCO_3>Na> SO_4>Mg>Cl>NO_3>NH_4> K>F>H. This order holds for arithmetic, geometric and volume-weighted means.

Thus, the study reveals that rainwater is alkaline, its acidity being neutralized by soil components Ca, Mg and ammonia. The soil components have a greater neutralizing effect. Another characteristic of precipitation at Agra is an excess of Ca, Na, Mg, SO_4 and Cl which are of non-sea-salt origin. The incorporation of soil material into the rain reflects a major continental influence.

Korba case study (Chandrawanshi *et.al.*, 1997).

Korba is an industrial city having major activities related to coal mining, thermal power plants, aluminium plant and several small scale industries using coal as the energy source. Acid rain has been detected in Korba with the major contribution being due to presence of high amount of sulphuric acid. Based on

the analysis of rain water samples collected during March to November 1995, the volume weighed average pH of rain water was 4.8.

Also, the mean concentration of the precursor gases, i.e., SO_2 and NO_x were found to be 70 and 61 $\mu g/m^3$, respectively. The mean volume weighed concentration of anions were determined and amongst them, the concentration of SO_4^{2-} was highest. The equivalent ratio of $[SO_4^{2-}]/[NO_3^-]$ was 8.5. The origin of SO_4^{2-}, NO_3^- and F^- in the rain water were expected mainly from the anthropogenic sources, i.e., coal burning process, melting of fluoride minerals, etc., whereas for Cl^- both the natural and anthropogenic sources were important. The average pH values of the rain water samples varied between 4.5-5.5 with volume weighed mean and median values of 4.8 and 4.9, respectively. The highest acidity of the rain water was recorded during monsoon period probably due to poor buffering capacity of soil dust blown. The percentage of acids, that is H_2SO_4, HNO_3, HCl + HF in rain water were determined and found to be 82.6, 9.7 and 7.6%, respectively. The coal burning process was expected to be the main source for the contribution of high amount of H_2SO_4 in rain water whereas aluminium plant was mainly responsible for the F^- ions.

Chembur-Trombay case study (Khemani *et.al.*, 1994)

Chembur-Trombay is one of the highly industrialised areas of the metropolitan city of Bombay. Substantial amounts of gaseous and particulate pollutants are released from the refineries, power plant, fertilizer plant, and many chemical industries which are located in the Chembur-Trombay area. In India, acid rain was first reported in this area (Sequeira, 1976) and the trend continued upto 1980. Thereafter, two major industries in this area, namely, Rashtriya Chemicals and Fertilizers (RCF) Limited and Tata Thermal Power Plant in Chembur-Trombay area switched over to natural gas instead of coal as fuel. In 1990, a well planned field observational programme for collection of rain water samples at Chembur-Trombay area during the southwest monsoon season, which is the major rainy period in the region, was undertaken.

It is surprising to note that average concentration of SO_2 around Chembur-Trombay area was reported 65 $\mu g/m^3$ during the period 1971-73, whereas the average concentration during 1990 was 15 $\mu g/m^3$. The drop in the concentration of SO_2 in this area is attributed to change in fuel from coal to natural gas used by thermal power plant and Rashtriya Chemicals and Fertilizers Limited, the major consumers of coal in this area.

The monthly average concentration of NO_2 was higher than that of SO_2 at five stations in the Chembur-Trombay area where it varied between 10 and 58 $\mu g/m^3$. The average concentration of NH_3 varied between 53 and 1295 $\mu g/m^3$.

Ionic composition of rain water.

The volume weighted means of the ionic components of rain water were calculated and are given in Table 4.

Table 4. Volume weighted averages of major ionic components in rain water in Chembur - Trombay area, also, reported values for Japan, Europe, China and USA are given for comparison.

	Concentration in $mg\ l^{-1}$								
	Cl^-	SO_4^{2-}	NO_3^-	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}	pH
Mean	5.84	3.38	1.83	0.74	3.87	0.27	1.79	0.44	6.44
Max/Min	1.56	2.84	5.30	8.40	1.56	1.40	1.38	1.41	-
Japan	2.15	2.54	1.16	0.48	0.99	0.13	0.74	0.15	4.7
Europe		0.9-4.4		0.1-2.7					4.1-5.4
China									
Acid rain area		5.4-19	1.0-2.0	0.9-1.9			0.1-4.6		4.1-4.9
Non-acid rain area		7.8-16	1.8-5.0	2.3-4.0			5.7-15.2		6.3-6.7
US									
Northwest		0.2-0.5	0.1-0.2	0.02-0.04			0.04-0.06		5.1-5.2
West middle west		1.0-1.5	0.9-1.9	0.2-0.7			0.2-0.7		5.0-5.5
Northwest		3.0-4.0	1.9-2.2	0.3-0.4			0.2-0.3		4.1-4.2

Source: Khemani *et.al.*, 1994

The maximum concentration of SO_4^{2-} (4.59 mg/l) was about five times lower than the value (20.2 mg/l) reported earlier from this area. The concentrations of NO_3^- varied between 0.88 and 4.67 mg/l. It may be noted that SO_4^{2-} is the major indicator of rain water acidity, NO_3^- an important secondary, and NH_4^+ and Ca^{2-} are the major buffers.

pH of rain water.

The average pH values at all the stations varied between 5.87 and 7.05. However, on very few occasions pH values were noted below 5.57, which were in the acidic range. The total percentage occurrence of acid rain at Vashi was maximum (8%). The coarse particles derived from the sea and soils contain alkaline components which tend to increase the pH of the rain water in which they are incorporated. The precipitation samples will be acidic or alkaline depending on the relative contribution of both aerosol size ranges to the total aerosol content of rain water. In this study, the mass size distribution of aerosols indicated dominance of the coarse particles over the submicron particles. Hence, the rain water should be alkaline, which is true as seen from the pH values of the rain water collected at 11 locations in Chembur-Trombay area.

The deposition of acidic components (SO_4^{2-} and NO_3^-)at Chembur-Trombay area is comparable with the values reported for the highly industrialised

countries like Japan and eastern North America (Barchet, 1983; Hara et al., 1990). However, the depositions of alkaline components (NH_4^+ and Ca^{2+}) were higher at Chembur-Trombay area than those at eastern North America and Japan. Hence, in spite of high level of deposition of individual SO_4^{2-} and NO_3^- which is comparable to the industrialised countries like Japan and United States, the rain water at Chembur-Trombay was not acidic.

Thus the salient features of this study are:

- The rain water which was previously acidic in Chembur-Trombay area (Sequeira, 1976) became alkaline in 1990. The pH values varied between 5.87 and 7.05. The occurrence of acidic showers was limited to 8% throughout the monsoon season. The high concentrations of alkaline components, especially Ca^{2+}, from natural sources and NH_3 released from the fertilizer plant, were responsible for neutralizing H^+ ion concentration.

- It is observed from the deposition values of NO_3^- and NH_4^+ that sources of trace gases emanating from the industries are very weak and can cause acidification only within short distances. On the other hand, the depositions of ionic components (Na^+, K^+, Ca^{2+}, Mg^{2+} and Cl^-) whose sources are natural and widespread, are substantial and, by and large, uniformly distributed throughout the region compared to those released from the anthropogenic sources.

- Most of the free acidity in rain water was contributed by sulphuric acid (63-75%) and remaining was contributed by nitric and other acids in the region. Hence, the concentration of SO_4^{2-} plays an important role for the acidification of rain water. There was no change in the concentration of alkaline components which remained, by and large, the same from 1974 to 1990. However, substantial change was observed in the case of acidic component SO_4^{2-}.

The RAINS-Asia Model

Introduction

RAINS-Asia (**R**egional **A**ir Pollution **IN**formation and **S**imulation model for Asia) is a user-friendly, integrated, PC-based model for regional policy analysis and decision making regarding energy sector development. It is a tool used to assess and project future trends in emissions, transport, and deposition of air pollutants and their potential environmental impacts. It is designed to help policy-makers and researchers in Asian countries in identifying cost-effective control options in an anticipatory manner for dealing with impacts resulting from acid depositions as a result of sulphur dioxide emissions. RAINS-Asia was developed by a team of Asian, European, and North American scientists, under the leadership of the World Bank and the Asian Development Bank.

The Asian countries are undergoing rapid economic growth and the demand for primary energy in Asia doubles every 12 years (compared with a world average of every 28 years). Fossil fuels account for about 80 percent of energy generation in Asia, with coal accounting for about 40 percent of the energy produced. Coal is expected to continue to be the dominant energy source, specially in China and India. Table 5 shows the total energy consumption by country for 1990 and 2020 (under the reference scenario), while Table 6 shows the corresponding sulphur dioxide emissions. At current energy consumption growth rates, by 2000, sulphur dioxide emissions from Asia will surpass the emissions of North America and Europe combined. Many ecosystems will be unable to absorb these increased acid depositions, leading to irreversible ecosystem damage.

Table 5. Total energy consumption by country (Petajoules/year)

Country	1990	Reference scenario 2020
China	30255	101016
India	15812	63621
Pakistan	1436	7361
S. Korea	3594	13448
Thailand	1688	9326
Indonesia	3793	13684
Philippines	585	3113
Japan	17866	28809
Asia Total	83594	274121

Source: RAINS-Asia Model

Table 6. Sulphur Dioxide (SO_2) emissions in 1990 and for the reference scenario in the year 2020 (in thousand tonnes of SO_2)

Country	1990	Reference scenario, 2020
China	21908	60688
India*	4479	18870
Pakistan	614	7527
S. Korea	1640	5537
Thailand	1038	4638
Indonesia	630	3162
Philippines	391	2037
Japan	835	1120
Asia Total	33675	110,478

Source: Downing *et.al.*, 1997; * RAINS-Asia7.02 version

Striking similarities exist between the challenges currently facing Asia and the European situation in the late 1960s, when declining fish population in Scandinavian countries first drew attention to the acid rain problem. Already, there is growing evidence of acid rain damage in several East Asian countries. A survey by the National Environmental Protection Agency indicates that about 40% of China's agricultural land is affected by acid rain.

Model description (Foell *et.al.*, 1995)

The RAINS-Asia model covers 23 countries in East, South and South-East Asia which are divided into 94 regions. The model uses 1990 data as a base and calculates future energy, emissions, and environmental parameters through 2020, in ten-year increments. The RAINS-Asia model consists of three modules, each addressing a different part of the acidification process. The Regional Energy and Scenario Generator (RESGEN) module estimates energy pathways based on socioeconomic and technological assumptions; the Energy and Emission module (ENEM) uses the energy scenarios to calculate sulphur emissions and costs of control strategies; and the Deposition and Critical Loads (DEP) module, which consists of the Atmospheric Transport and Deposition (ATMOS) sub-module and the Environmental Impact and Critical Loads (IMPACT) sub-module, calculates the levels and patterns of sulphur deposition resulting from a given emission scenario and the ecosystem critical loads and their environmental impacts based on these patterns.

The RESGEN module estimates present and future energy supply and consumption levels based on a variety of socioeconomic and technological assumptions. RESGEN estimates energy use for six end-use sectors, for 23 countries and for 17 different fuel types. A total of 94 sub-country regions are defined, including 22 mega cities and one region representing international shipping lanes. The fuel types include various qualities of coal, other solid fuels, fuel oil, natural gas, renewables, hydro power and nuclear power. The six end-use energy sectors are residential, commercial, industrial, transportation, agriculture and non-energy use of fuels. With RESGEN, a user can select, review, and modify the following critical parameters on the regional level: socioeconomic data, end use sectoral energy demand, fuel types used and fuel characteristics. Two energy demand scenarios have also been developed: base-case scenario and an energy-efficiency scenario.

The atmospheric module (ATMOS) of RAINS-Asia analyses long-range transport and deposition of sulphur in Asia. ATMOS combines information on emission rates, levels and source locations (from ENEM) with meteorological, chemical, and physical data to calculate the resulting sulphur deposition patterns. The ATMOS model, which is a three-dimensional, multiple layer lagrangian model, is used for calculations. It is a modified version of the NOAA's Branching Atmospheric Trajectory (BAT) model. The model provides annual average (wet+dry) sulphur (sulphur dioxide and sulphate) deposition values and monthly average sulphur dioxide concentration values for each 1 degree by 1 degree grid cell. The model allows the user to assess the spread of pollution from an individual source or region. The emission sources that contribute to sulphur deposition at a particular site can also be identified.

The IMPACT submodule assesses the sensitivity of various ecosystems to acid deposition and compares this information to the deposition data generated by the ATMOS module. The carrying capacity of acid deposition of 31 types of

ecosystems is estimated. Values of sulphur deposition are based on a yearly average and are calculated at a 1 X 1 degree resolution.

As mentioned earlier, currently, the model is designed to analyse emissions and environmental impacts of sulphur dioxide. It assesses only the indirect effects of sulphur deposition on soil. The steady-state mass balance method is used to calculate critical loads in the RAINS-Asia impact sub-module. The steady-state mass balance method determines the maximum level of a substance (sulphur based acidity in the present case) that will not damage an ecosystem over the long run.

Model results

RAINS-Asia model results indicate that in the base case (reference) scenario, there would be a tripling of energy use during the period 1990-2020 and the total emissions would more than triple (33.6 million tons in 1990 to 110 million tons in 2020). Many industrialized areas of China, Indonesia, Malaysia, the Philippines, and Thailand would experience very high sulphur deposition levels. In 2020, large portions of southern and eastern China, northern and eastern India, parts of northern and central Thailand and much of Korean peninsula will experience sulphur deposition levels that exceed the ecosystem critical loads in those areas.

A major feature of the RAINS model is its capability to simulate sulphur dioxide emission control strategies and explore their costs and regional environmental benefits in physical terms. Various control technologies such as basic control technology (BCT), best available technology (BAT) and advanced control technology (ACT) are considered. As an illustration, drastic reductions in sulphur dioxide emissions can be achieved under the BAT scenario, whereby the emissions decrease by more than 50 percent from 1990 to 2020. Whereas the reference scenario is a worst-case analysis of the future situation, the BAT method can be seen as a best-case approach. However, the costs associated for carrying out the BAT strategy across Asia are extremely high, approx. US$90 billion per year.

India specific results of RAINS-Asia model

Based on the results from the RAINS model, it is seen that the energy consumption under the base (business-as-usual) scenario increases from 15812 peta joules (PJ) to 63621 PJ during the period 1990-2020, thereby showing an increase of 302%. The SO_2 emissions during the same period show an even greater increase of 321% i.e. from 4.48 million tonnes (Mt) to 18.87 Mt (Table 7).

Table7. SO_2 emissions and energy consumption by fuel for India

Fuel	SO_2 emissions (thousand tons of SO_2)				Energy consumption (PJ)			
	1990	2000	2010	2020	1990	2000	2010	2020
Coal	2187	3203	5529	9449	4308	6163	10278	17223
Oil	1291	2146	3919	7480	2351	4311	9282	21512
Others	1001	1270	1631	1942	9152	12434	17372	24886
Total	4479	6619	11079	18871	15811	22908	36932	63621

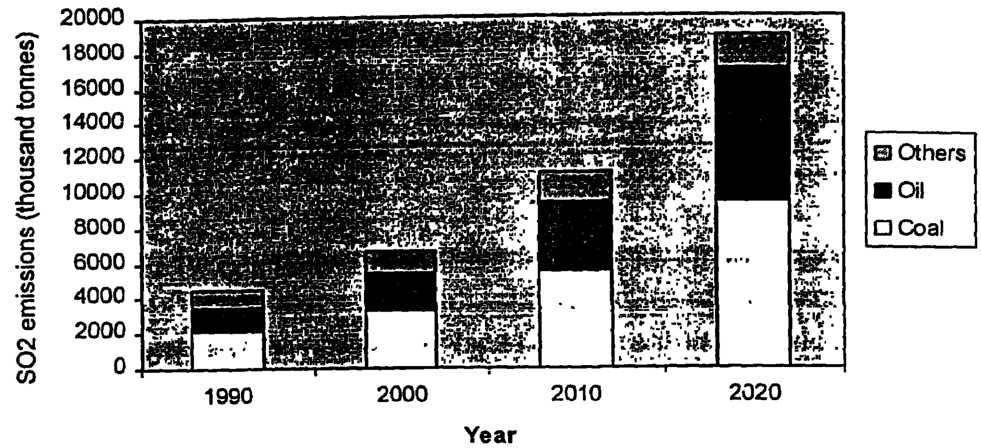
Source: RAINS-Asia 7.02 version

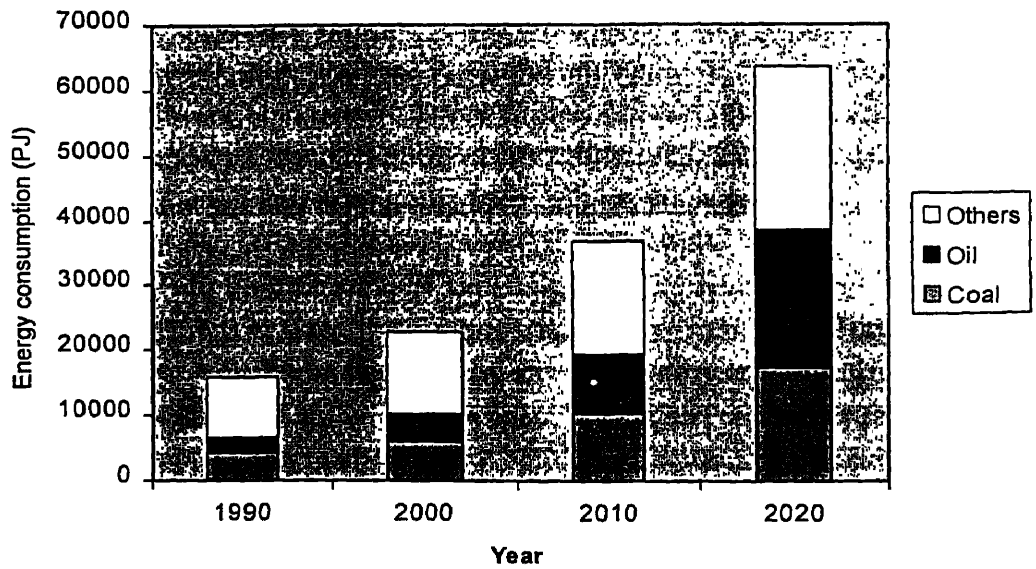
The percentage of SO_2 emissions from coal and oil are 49 and 29%, respectively in 1990 and subsequently increase to 50 and 40% in 2020. This is basically due to the share of coal in the total energy consumption being roughly the same (27%) while that of oil increases from about 15% to 34% during the period 1990-2020 (Figure 4).

The steep increase in SO_2 emissions resulting from the high growth energy consumption will cause a strong increase in sulphur deposition. One way to judge the potential environmental damage caused by increased sulphur deposition is to compare deposition with critical loads, which resemble the maximum deposition that will not cause chemical changes leading to harmful effects on the ecosystem.

Figures 5 and 6 show the excess sulphur deposition above critical loads in 1990 and 2020 under the reference scenario. It is clearly evident that in 1990, the excess sulphur deposition was restricted only a few locations. However, the situation changes significantly in 2020 whereby large regions in northern and eastern India show sulphur deposition level that exceed the critical load in those areas. Many regions experience excess sulphur deposition between 2 to 5 gms/sqm/yr. It may be noted here that even under the highest emission scenario considered here, the western and central parts of India do not experience excess sulphur deposition above the critical load mainly due to the alkaline nature of the soil particles. The critical loads for acidity for India are shown in Figure 7. As a conservative assumption the 25 percentile of critical loads database has been used for this analysis, allowing for eventual uncertainties and data inaccuracies in the quantitative estimates of the critical loads. Since a single grid cell can contain numerous combinations of vegetation, soil type and other factors that influence the critical load, the map shows critical load values that protect 75% of all ecosystem in that grid cell.

Figure 4. SO_2 emissions and energy consumption by fuel for India





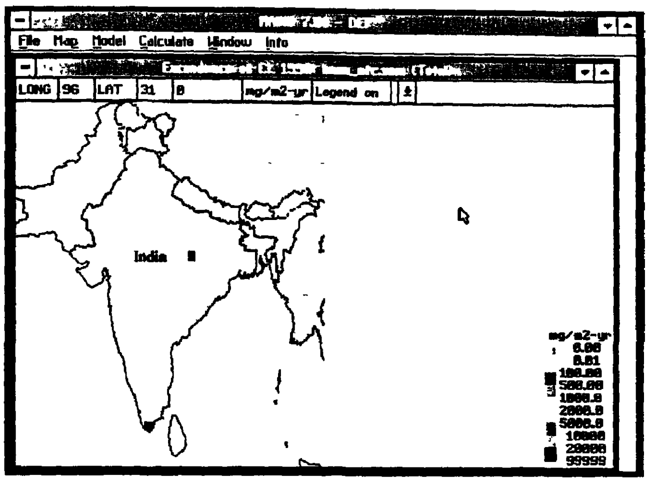


Figure 5: Excess sulphur deposition above critical loads in 1990

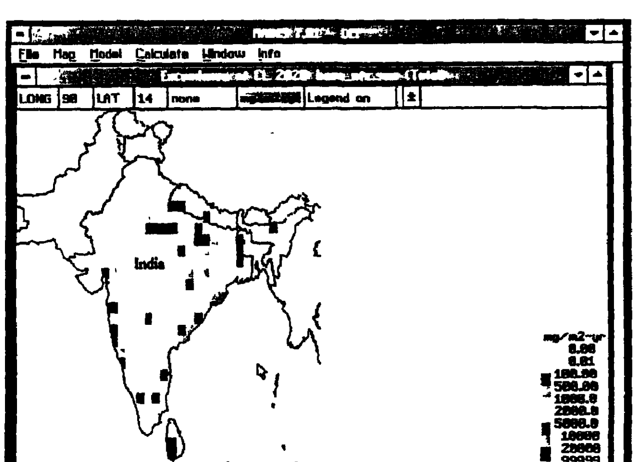


Figure 6: Excess sulphur deposition above critical loads in 2020 under reference scenario

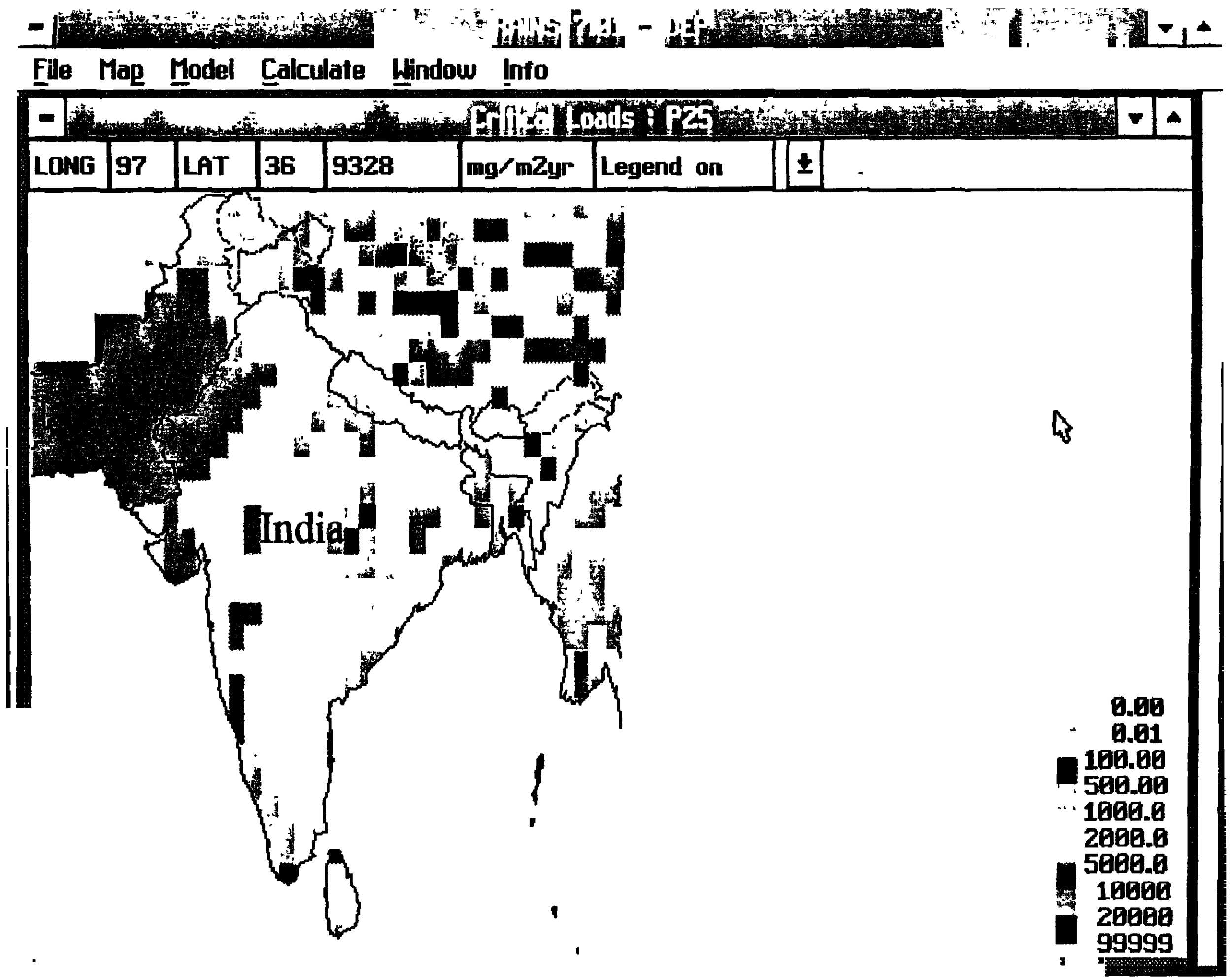


Figure 7: Critical loads (mg/m^2 - yr) for acidity for India

The RAINS model is capable to simulate SO_2 emission control strategies and explore their costs, and their regional environmental benefits. Table 8 shows the SO_2 emissions and the associated control costs under various control technology scenario i.e. best available technology (BAT), advanced control technology (ACT), basic control technology (BCT), and local application of advanced technology (LACT).

Table 8. Emissions and abatement costs for India under various control scenarios

Scenario	Emissions (thousand tonnes of SO_2)			Abatement cost (million US$/yr)		
	2000	2010	2020	2000	2010	2020
Base-BAT	2058	3389	5906	5721	9370	17055
Base-BCT	5074	7970	13054	1887	3424	6213
Base-LACI	5505	8408	13435	1060	2024	3892
Base-ACT	4752	6866	10522	1834	3379	6337
Efficiency BAT	1784	2684	4476	4781	7279	12357

Source: RAINS-Asia 7.02 version

BAT: Best available technology; BCT: Basic control technology; LACT: Local applications of advanced technology

ACT: Advanced control technology

In the RAINS model, measures considered under BAT scenario include use of wet flue gas desulphurization (WFGD) for all existing and new large industrial power plants burning coal and oil. The use of low sulphur fuels has been assumed for all small sources. The ACT scenario assumes application of advanced control technology (WFGD) only for new, large emission sources in power plant, industrial and refining section. Emission from existing power stations and small sources in industry are assumed to be controlled through use of low sulphur fuels. For domestic and transport sector, low sulphur fuels are used. Under the BCT scenario, emissions for new large point sources are controlled by domestic technology (with typical removal efficiency of about 50%, eg. limestone injection) for all new coal fired power plants. For small sources in industrial and domestic sector, use of low sulphur fuels is assumed. The LACT scenario focuses on application of advanced emission controlled measures to only those provinces where significant excess deposition would occur without such measures.

In the base scenario, with application of BAT control measures the emissions show a decrease by 69% in 2020 as compared to reference scenario. The control costs associated are just as striking as the environmental improvements. It is estimated that in 2020, the costs of carrying out the BAT strategy are 17055 Million US$. The effect on critical loads exceedance is also remarkable. Whereas the reference scenario is a worst case analysis of the future situation, the BAT method can be seen as a best case approach.

The SO_2 reductions under the ACT, LACT and BCT control scenarios are 44%, 29% and 31%, respectively compared to the reference scenario. The costs too vary from 3892 Million US$ per year for LACT scenario to 6337 Million US$ for ACT scenario. As expected with the use of less effective emissions control technology, emissions level in BCT scenario are considerably higher than those projected for other more stringent scenario such as ACT. Nevertheless, total control costs are roughly the same for the two scenarios, primarily because the model calculates

total life cycle costs for emissions control technologies. Although the controls implemented in the BCT scenario require less up-front capital investment, they have higher operating costs.

It is well known that energy policies promoting energy efficiency and use of cleaner fuels are important instrument to reduce pollution and pollution control costs. Under the energy efficiency-BAT scenario, the SO_2 emissions for India reduce by 24% as compared to the base - BAT scenario and the total control costs too are reduced by about 27%.

If no counter measures are taken, an initial analysis with the RAINS model indicates that currently observed trends in energy consumption will impose significant environmental threats to the ecosystems in many parts of India. There are a variety of measures that can be taken to reduce SO_2 emissions and thereby avoid excess deposition. Advanced emission control technologies could reduce emissions below current levels even in a high growth energy scenario, albeit at extremely high costs. However, potential exists for an increase in the cost effectiveness of strategies if measures are focussed on specific fuels, technologies, economic sectors, emission sources or ecologically sensitive regions. The analysis also shows that energy planning is an important factor for controlling adverse environmental effects.

Use of RAINS model

In the light of the disturbing trends related to acid deposition, it is important to apply the lessons learnt in the West to address the air pollution problems in Asia. Experience in addressing large scale environmental problems has shown that it is much cheaper to implement measures to prevent environmental hazards than to clean up the pollution once it has occurred. This proactive method of environmental management, using tools such as RAINS-Asia model, helps to ensure that the most effective and efficient policies can be identified and implemented. The broad geographic nature of the problem requires national and regional problem solving as a key to developing workable, long term strategies to reduce or prevent the environmental effects of air pollution.

The RAINS-Asia model can be used for a variety of purposes: energy and environmental planning; identifying critical ecosystems and their sulphur carrying capacities; following emissions from an area or point source to estimate deposition; identifying the sources contributing to deposition in an ecosystem; exploring different mitigation strategies and associated costs; selecting predefined energy pathways; modifying pathways to explore effects of alternative energy development strategies; and defining control strategies for individual fuel types, economic sectors, emissions control technologies, and subregions or countries.

Future development

Although the RAINS-model has some limitations in its current stage of development, it still provides a useful tool for looking at future scenarios of energy growth and resulting environmental consequences. Further involvement of in-country policy makers, managers and scientists is needed to refine the model. Some of the possible improvements in the model include update of inventory, meteorology improvement, additional pollutants, model validation, etc.

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DEPOSITION AND DISPERSION ASPECTS OF RAINS-ASIA

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GOAL OF THE PROJECT

IN RECENT YEARS, INTEGRATED ASSESSMENT MODELS HAVE BEEN UTILIZED FOR INTERNATIONAL NEGOTIATIONS ON ACID RAIN.

THESE MODELS PROVIDE A FULL REGIONAL PICTURE OF THE PROBLEMS FROM ENERGY SYSTEMS AND EMISSIONS TO THE ULTIMATE IMPACT ON NATURAL AND MAN-MADE SYSTEMS.

SUCH AN EFFORT IN EUROPE HAS LED TO THE RAINS-EUROPE MODEL- USED FOR SIGNING SECOND SULFUR PROTOCOL BY 33 COUNTRIES TO CONTAIN SO_2 EMISSIONS.

WITH ACTIVE SUPPORT OF WORLD BANK, A COMPLETE ASSESSMENT METHODOLOGY FOR THE ACID RAIN IMPACTS IN ASIA IS SOUGHT TO BE DEVELOPED, AS DONE FOR EUROPE.

RAINS-ASIA WAS DEVELOPED ON THE LINE OF RAINS EUROPE.

RAINS-ASIA WAS AIMED TO BE AN INTEGRATED ACID RAIN AND EMISSIONS POLICY ANALYSIS MODEL FOR THE DEVELOPMENT OF NATIONAL AND REGIONAL POLICY PERSPECTIVE IN ASIA.

RAINS ASIA CONSISTS THREE MODULES.

~ ENERGY AND EMISSION MODULE (ENEM)
~ ATMOSPHERIC MODULE (ATMOS)
~ IMPACTS MODULE (IMPACT)

SEPARATE MODULES ALLOWS EASY REPLACEMENT IF REQUIRED TO NCLUDE MORE FACTS.

IT COVERS EAST, SOUTH AND SOUTH-EAST ASIA WITH THE PARTICULAR FOCUS ON CHINA, INDIA, THAILAND, NORTH KOREA AND SOUTH KOREA.

TEMPORAL RANGE OF ALL THE MODEL IS 1990-2020 WITH TIME RESOLUTION OF ONE YEAR.

COMPONENTS TO BE DEVELOPED

(A) ENERGY AND EMISSIONS MODULE AND ENERGY ECONOMIC ANALYSIS,

(B) ATMOSPHERIC TRANSPORT AND DEPOSITION MODULE,

(C) ECOSYSTEM SENSITIVITY EVALUATION AND MAPPING FOR ASIA,

(D) CRITICAL LOAD EVALUATION AND MODEL INTEGRATION MODULES, AND

(E) ASIAN COUNTRIES DATA COLLECTION AND INSTITUTIONAL DEVELOPMENT.

ATMOSPHERIC TRANSPORT AND DEPOSITION MODULE

DEVELOPMENT OF ACID DEPOSITION DISPERSION MODEL FOR ASIA (10S- 50N & 60E-160E) TREATING EMISSIONS FROM ELEVATED SOURCES.

SELECTION OF MODEL PARAMETERS, TAKING INTO ACCOUNT HIGH LEVEL OF DUST AND TROPICAL CONDITIONS.

SELECTION OF BASE YEAR AND REPRESENTATIVE METEOROLOGICAL CONDITIONS.

CALCULATION OF ANNUAL SULFUR DEPOSITION (WET, DRY AND TOTAL) ON GRID TO GRID BASIS-ALONG WITH SURFACE CONCENTRATION.

DEVELOPMENT OF POST PROCESSING TOOLS.

IDENTIFY OBSERVATIONAL DATA FOR MODEL VERIFICATION.

OBTAIN DATA ON THE BASE-CATION COMPOSITION FOR FUTURE STUDIES ON BASE-CATION DEPOSITION.

ESTABLISH A NETWORK OF SCIENTISTS FOR DEVELOPMENT AND APPLICATION OF MODEL.

DELIVER THE DISPERSION MODEL FOR USE AS A TOOL TO STUDY LONG RANGE TRANSPORT OF AIR POLLUTANTS IN THE ASIA.

ATMOS MODEL

* *A Long range transport and deposition model (referred as ATMOS Model) for sulfur in asia has been developed.*

* *The model is a Lagrangian parcel model with three vertical layers.*

* *The model calculates the ambient concentration, and the wet and dry deposition of SO_2 and sulfate resulting from area and large point source.*

* *The model produces transfer matrices region-to grid matrix for the area source and a large point source-to-grid matrix for the elevated sources for use in the RAINS-ASIA-Model to calculate future sulfur deposition under various emissions.*

* *Annual deposition of sulfur as a function of SO_2 emissions is the basic product of ATMOS Module.*

* *The phase I Project concentrates only on sulfur, the dominant anthropogenic acid precursor emitted from energy use in Asia.*

* *NOAA Branching Atmospheric Trajectory (BAT) model is modified and used for ATMOS activities.*

* *The model is used for 1990 Base year and results were incorporated in RAINS-ASIA model.*

ATMOSPHERIC TRANSPORT AND DEPOSITION (ATMOS) SUBMODULE RAINS-ASIA.

THE ATMOS MODULE PROVIDES ESTIMATES OF AMBIENT LEVELS & PATTERNS OF SO_2, SULFATE, AND SULFUR DEPOSITION (WET DRY AND TOTAL) THROUGHOUT ASIA THAT RESULT FROM VARIOUS ENERGY AND EMISSIONS SCENARIOS. THESE ESTIMATES PROVIDE THE LINK BETWEEN EMISSIONS AND DEPOSITION, AND THEY ARE A MAJOR INPUT INTO THE RAIN -ASIA MODEL. IT SPECIFICALLY PROVIDES A MATRIX FOR EACH 1° BY 1° GRID CELL WHICH INCLUDES ANNUAL DEPOSITION OF SULFUR AND SO_2 LEVELS AS A FUNCTION OF SO_2 EMISSIONS.

- CONCENTRATION AND DEPOSITION VALUES ARE CALCULATED SEPARATELY FOR LARGE POINT AND AREA SOURCES.
- FOR DISPERSED AREA SOURCES, THE RESULTS ARE AGGREGATED SHOWING EACH REGION'S CONTRIBUTION TO DEPOSITION IN A PARTICULAR GRID CELL.
- EMISSIONS FROM EACH LARGE POINT SOURCE ARE CALCULATED INDIVIDUALLY AND SHOW THE CONTRIBUTION OF EACH LARGE POINT SOURCE TO EACH GRID CELL.

MODEL DOMAIN:

- THE REGION COVERED BY THE MODEL RANGES

FROM 10°S TO 55°N LATITUDE AND FROM 60° TO 150° EAST LONGITUDE, COVERING THE COUNTRIES OF EAST, SOUTH, AND SOUTHEAST ASIA. IT COVERS A TOTAL OF NINETY FOUR REGIONS IN 21 COUNTRIES 22 OF THESE REGIONS ARE MAJOR METROPOLITAN AREAS AND INTERNATIONAL SEA LANES CONSTITUTE ONE REGION.

MODELING FRAMEWORK :

- ACID DEPOSITION MODELS ARE COMPUTER BASED MODELS WHICH CALCULATE THE DISTRIBUTION OF TRACE GASES THE IN THE TROPOSPHERE FROM SPECIFIED EMISSIONS DISTRIBUTIONS AND METEOROLOGICAL

SCENARIOS. THE BASIC FORMULATION OF THESE MODELS CONSIST OF.

1. <u>TRANSPORT</u> :

THIS IS TO DESCRIBE THE WIND SPEED AND DIRECTION, THE EDDY DIFFUSIVITY AND MIXING HEIGHT, TEMP., WATER VAPOUR, CLOUD WATER CONTENT, AND THE RADIATION INTENSITY OF EACH LOCATION AS A FUNCTION OF TIME.

2. <u>CHEMICAL KINETIC MECHANISMS</u>:

THESE ARE TO DESCRIBE THE RATES OF ATMOSPHERIC REACTIONS, INCLUDING HOMOGENEOUS GAS PHASE, HETEROGENEOUS,

AND LIQUID PHASE REACTIONS.

3. REMOVAL MODELS :

TO DESCRIBE THE DRY DEPOSITION OF MATERIAL AND THE IN - CLOUD AND BELOW CLOUD REMOVAL PROCESSES.EACH PROCESS WHICH IS INCORPORATED IN THE MODEL IS A VERY COMPLEX PHENOMENA. THUS THESE ARE INCORPORATED IN THE MODEL BY UTILIZING CHEMICAL, DYNAMIC AND THERMODYNAMIC PARAMETERISATANTIONS.

IN ADDITION, THERE ARE TWO BASIC APPROACHES WHICH COULD BE UTILIZED TO MODEL THE ATMOSPHERIC DISPERSION OF

POLLUTANTS.

(A) EULERIAN FRAMEWORK.

(B) LAGARANGIAN FRAMEWORK.

BOTH THE FRAMEWORK, HOWEVER ARE BASED ON THE ATMOSPHERIC ADVECTION-DIFFUSION EQUATIONS OR THE MASS BALANCE EQUATIONS.

DESCRIPTION OF THE ATMOS MODEL :

- **THE MODEL IS A MODIFIED VERSION OF NOAA'S AIR RESOURCES LABORATORY BAT (BRANCHING ATMOSPHERIC TRAJECTIORY) MODEL.**

- THE ATMOS MODEL IS A 3-D, MULTIPLE LAYER LAGRANGION MODEL.

- WITHIN THE MODELING DOMAIN SO_2 EMISSION PLUMES ARE MODELED AS PUFFS RELEASED EVERY 3 HOURS FROM THE EMISSION SOURCE LOCATION.

- EACH PUFF IS ASSIGNED A MASS PROPORTIONAL TO THE SOURCE STRENGTH AND IS ASSUMED TO MIX UNIFORMLY IN THE VERTICAL THROUGHOUT AN ASSIGNED LAYER.
- ALSO, DIFFUSION IN THE HORIZONTAL IS ASSUMED GAUSSIAN.

- INDIVIDUAL EMISSION PUFFS ARE FOLLOWED THROUGHOUT THEIR TRANSPORT AND DEPOSITION. EACH PUFF'S TRANSPORT IS FOLLOWED FOR UPTO 5 DAYS OR THE MASS FALLS BELOW A CUT-OFF VALUE.
- PUFFS WHICH ARE TRANSPORTED BEYOND THE MODELING DOMAIN ARE NO LONGER TRACKED.

- AREA EMISSIONS ARE MODELED AS SURFACE SOURCES WHILE LARGE POINT SOURCES AND VOLCANOES ARE TREATED AS ELEVATED SORUCES.

VERTICAL MIXING

- THE MODEL SEPARTES THE VERTICAL

DIMENSION INTO 2 LAYERS DURING DAYTIME AND THREE LAYERS AT NIGHT.

THE DAY LAYERE ARE : BOUNDARY AND UPPER LAYERS.

THE NIGHT LAYERS ARE SURFACE, BOUNDARY AND UPPER LAYERS.

THE BOUNDARY AND UPPER LAYERS ARE SEPARATED BY CRITICAL INVERSION. THE SURFACE LAYER AT NIGHT PLAYS AN IMPORTANT ROLE IN KEEPING THE MATERIAL FROM REACHING THE SURFACE.

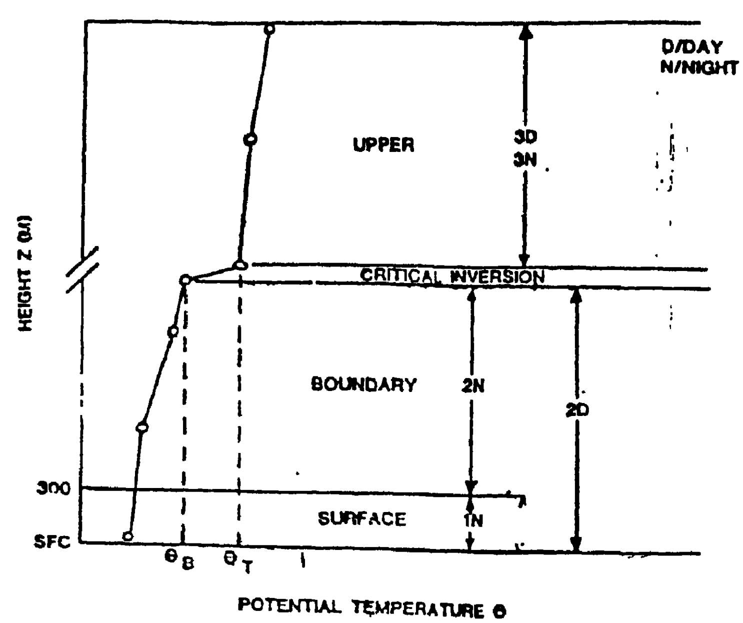

Figure 4. Multiple vertical layers used in the ATMOS model (from Heffter , 1983).

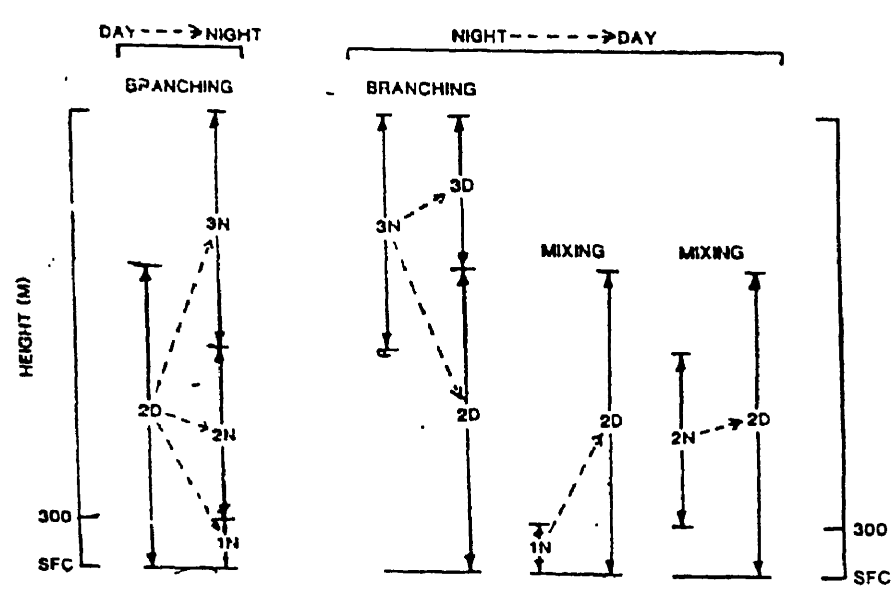

Figure 5. Branching and mixing in the ATMOS model (from Heffter, 1983).

THE ATMOSPHERIC MODULE OF RAINS ASIA

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- THE MAXIMUM HT FOR THE MODEL IS 6000 M AND MAXIMUM BL HT IS 2500 M.

- DURING DAY-TO-NIGHT AND NIGHT TO DAY TRANSITION THE PUFF BRANCHES INTO MULTIPLE PUFFS TO SIMULATE VERTICAL WIND SHEARING OF THE PUFF.

- UPTO 32 BRANCHES OF THE ORIGINAL PUFF MAY BE TRACKED SIMULTANEOUSLY AFTER WHICH BRANCHING CEASES.

CONCENTRATION AND DEPOSITION CALCULATIONS

- THE GASEOUS SO_2 AND AEROSOL SULFATE ARE TREATED EXPLICILY. SULFATE IS BOTH EMITTED

DIRECTLY (ESTIMATED AS 5% OF THE TOTAL SULFUR EMITTED) AND FORMED FROM THE CHEMICAL CONVERSION OF SO_2.

- THE DIFFUSION CALCULATIONS ARE ON HOURLY BASIS.

- DEPOSITION IS SEPARATED INTO DRY AND WET SO_2 AND DRY AND WET SULFATE.

- ONLY THE MASS PRESENT IN THE NIGHT SL AND DAY BL CONTRIBUTE TO THE DRY DEPOSITION VALUES. MASS IN ALL LAYERS CONTRIBUTE TO THE WET DEPOSITION.

- **THE MASS OF SULFUR, AND THE PARTITIONING OF SULFUR BETWEEN SO_2 AND SULFATE WITHIN EACH PARCEL J IS CALCULATED EVERY HOUR BY SOLVING THE MASS BALANCE EQUATIONS.**

- **THE CONCENTRATION IN A GIVEN LAYER AT EACH GRID POINT WITHIN THE MODEL DOMAIN ARE CALCULATED BASED ON THE MASS OF EACH PUFF IN THAT LAYER. ONLY THOSE PUFFS THAT COME INTO CONTACT WITH THE SURFACE CONTRIBUTE TO THE SURFACE CONCENTRATION.**

- THE MASS IS ASSUMED TO BE UNIFORMLY MIXED IN THE VERTICAL WITHIN A LAYER AND DISTRIBUTED IN A GAUSSIAN FASHION IN THE HORIZONTAL.

- THE CONCENTRATION OF THE PUFF AT A SPECIFIC LOCATION IS GIVEN BY THE GAUSSIAN PLUME FORMULA, WHICH DEPENDS ON THE PUFF MASS, THE HORIZONTAL DISPERSION, THE HT OF THE SURFACE LAYER, AND THE DISTANCE FROM THE PUFF CENTRE.

- **THE CONCENTRATION AROUND THE PUFF CENTER IS CALCULATED FROM**

SO_2(lat, long, t+Dt) = MSO_2(j, t+Dt)/(2PI*σ^2*L)V * exp(-r^2/2*σ^2)

SO_4(lat,long, t+Dt) = MSO_4(j, t+Dt)/(2*PI*σ^2*L)V * exp(-r^2/2*σ^2)

Σ - HORIZONTAL MASS STANDARD DEVIATION

L - LAYER DEPTH, WEIGHTED ACORDING TO THE SQUARE OF INVERSE DISTANCE OF THE CONTRIBUTING RAWINSONDE, AND

R - DISTANCE FROM THE PUFF CENTRE

V - VOLUME OF THE GRID CENTERED AT LAT, LONG WITH A LAYER THICKNESS OF ZI.

ONLY THOSE PUFFS IN THE LOWEST VERTICAL LAYER CONTRIBUTE TO DRY

DEPOSITION WET DEPOSITION TAKES PLACE THROUGHOUT THE VERTICAL COLUMN AND IN THROUGH PRECIPITATION.

DRY & WET DEPOSITION ARE CALCULATED AS FOLLOWS :

DRY SO_2(lat, long, t+Dt) = DRY SO_2(lat, long, t+Dt) + SO_2(lat, long, t+Dt) * V_d SO_2 * Dt

WET SO_2(lat, long, t+Dt) = WET SO_2(lat, long, t) + SO_2(lat, long, t) + SO_2(lat, log, t+Δt) *kw-SO_2 *Zi*Δt

kw represents the wet removal rate constants, V_d is the dry deposition velocity.

INPUT DATA.

METEROLOGY DATA.

RAWINSONDE AND PIBAL VERTICAL OBSERVATIONS FOR WS & TEMP FROM SURBACE TO 500 IS USED AT SIX HOUR INTERVALS FOR 1990 WHICH WERE PROVIDED BY NMC. & NOAA. IF NO WIND DATA IS AVAILABLE WITHIN THE 5° RADIUS CLIMATOLOGICAL VALUES WERE USED.

PRECIPITATION DATA.

THE DATA USED WAS NMC ANALYSED FICLDAS OBTAINED FROM USA'S NCAR.

EMISSION.:

DETAILS PROVIDED FOR THIS IS PART OF RAINS-ASIA & IN RESGEN.

SO_2 MONITORING DATA :

SO_2MONITORING THROUGH PASSIVE DIFFUSION SAMPLERS.

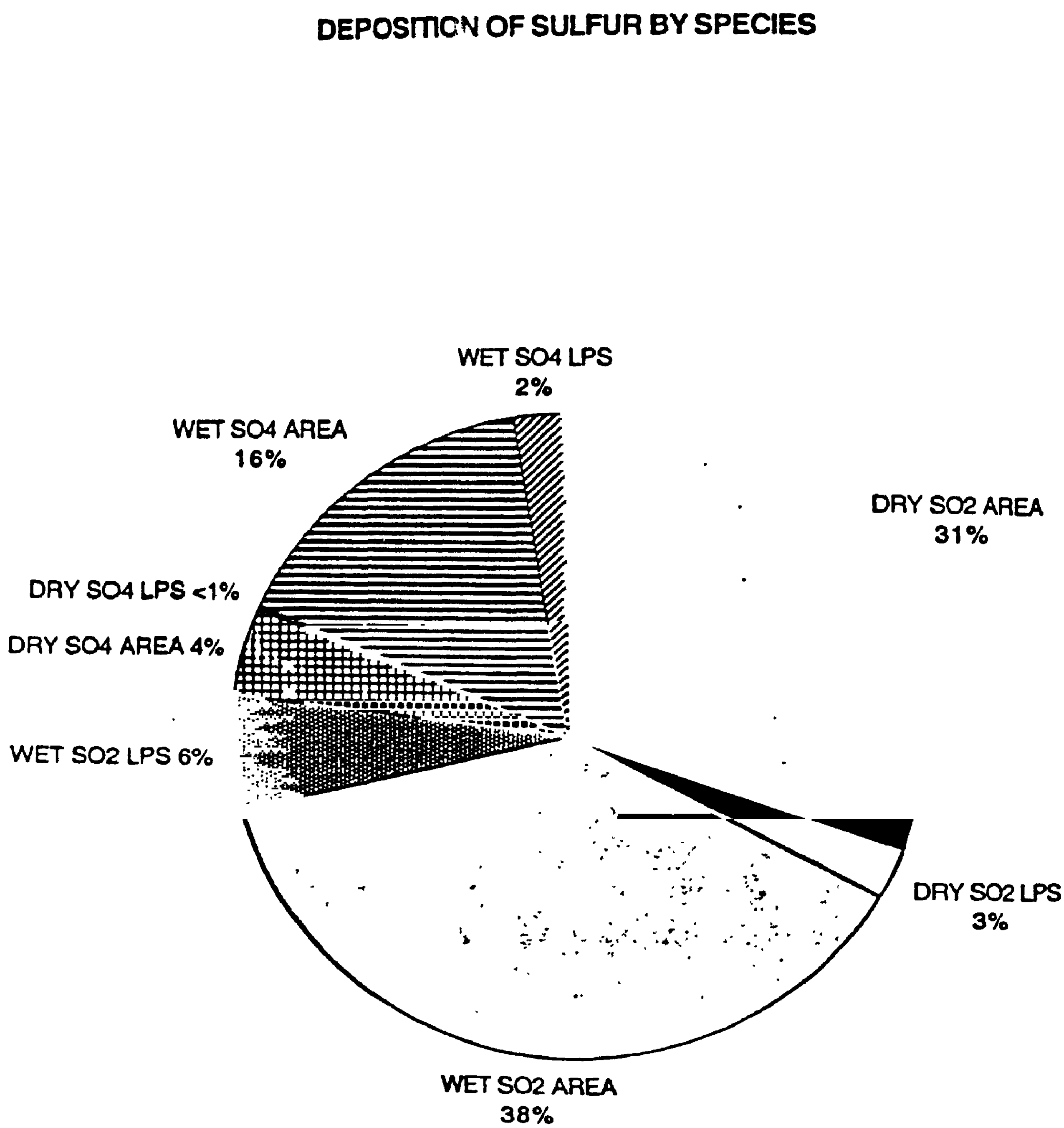
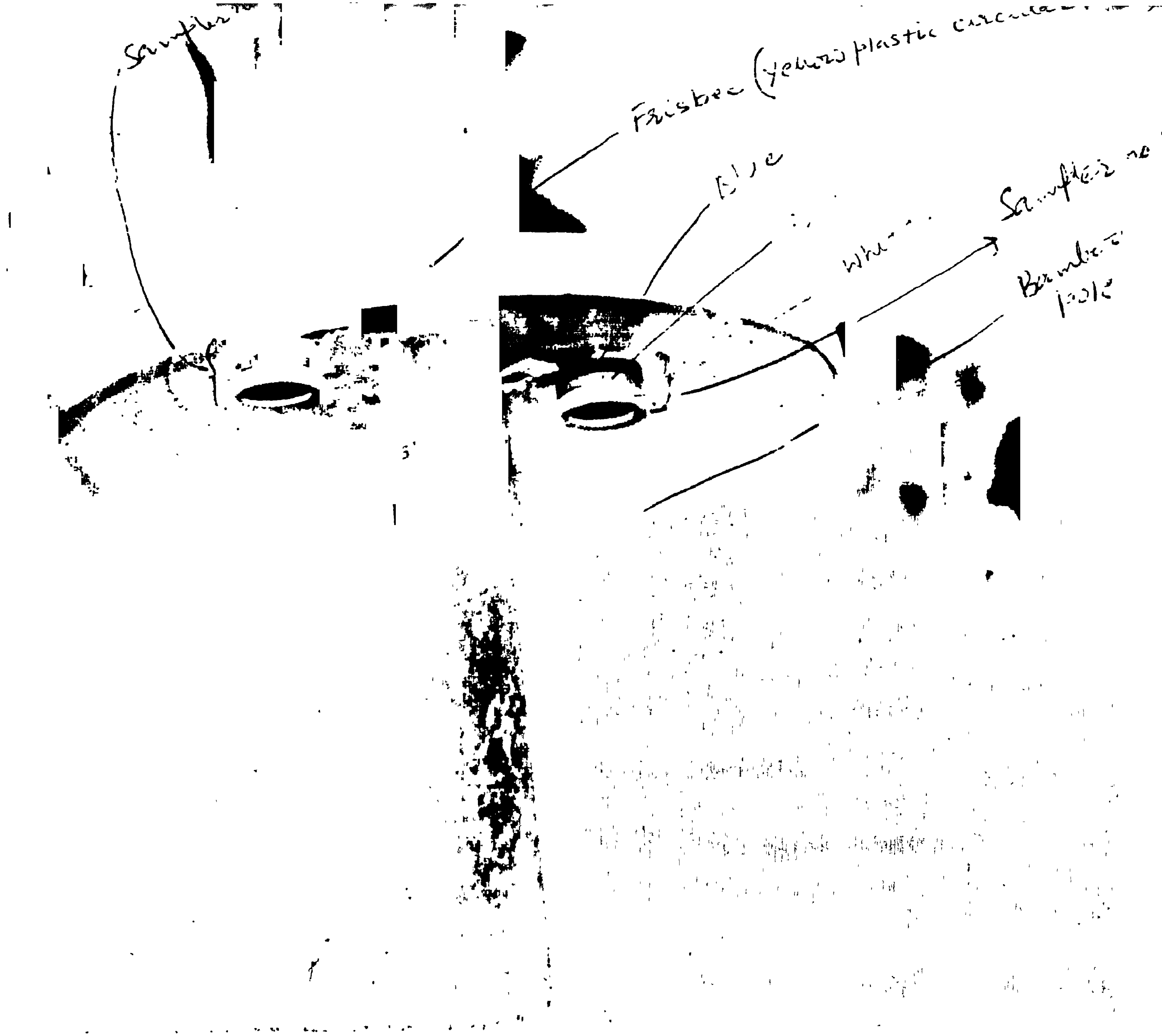


Figure 5.12. Domain-integrated annual deposition of sulfur by form and mechanism.

Table 5.5. SO_2 Passive Sampler Monitor Network for RAINS/ASIA

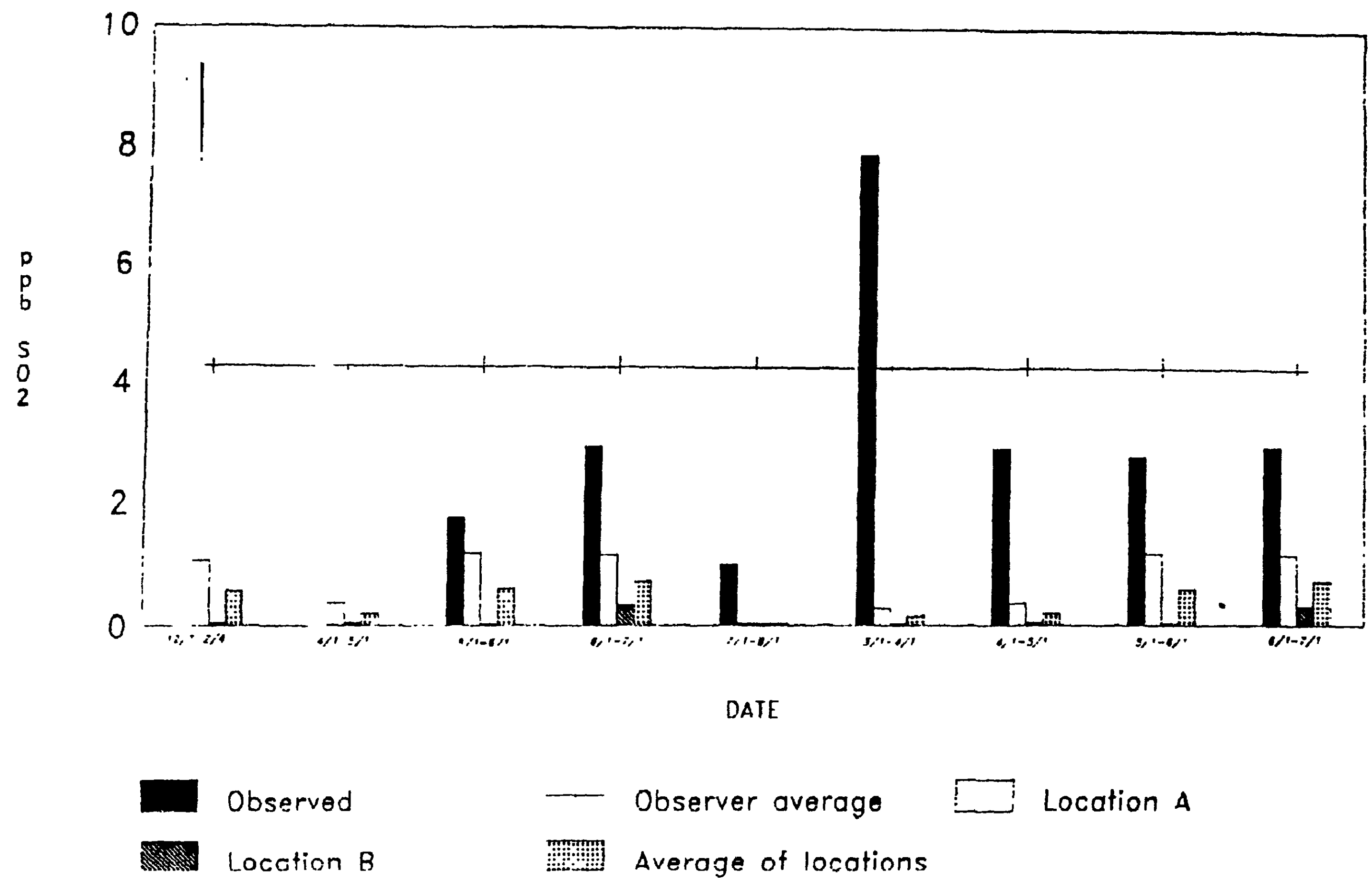
Country	# Sites	Contact Person
India	10	Prof. Manju Mohan, Center for Atmospheric Sciences, IIT New Delhi
Nepal	5	Dr. S.P. Adhikary, Director General Nepal Meteorological Services
Korea	3	Prof. M. Hong, Ajou University, Suwon
Thailand	5	Mr. Kanog Suksomsankh, Environmental Research & Training Center
Malaysia	5	Dr. Lim Fook, Malaysia Meteorological. Agency
Indonesia	4	Prof. Soedomo, Inst. of Tech., Bandung
Taiwan	1	Prof. Liu, Taiwan National University
Hong Kong	1	Dr. Chan, Hong Kong Polytech University
Vietnam	2	Dr. Gian, Inst. of Chemistry, Hanoi
Bangladesh	2	Prof. Ahmad, Jahangirnagar University
China	5	Prof. Zhao, Eco-Environmental Center, Academia Sinica
Sweden		Dr. Martin Ferm, SERI


Sampler
Frisbee (yellow plastic circular
Blue
White
Sampler no
Bamboo pole

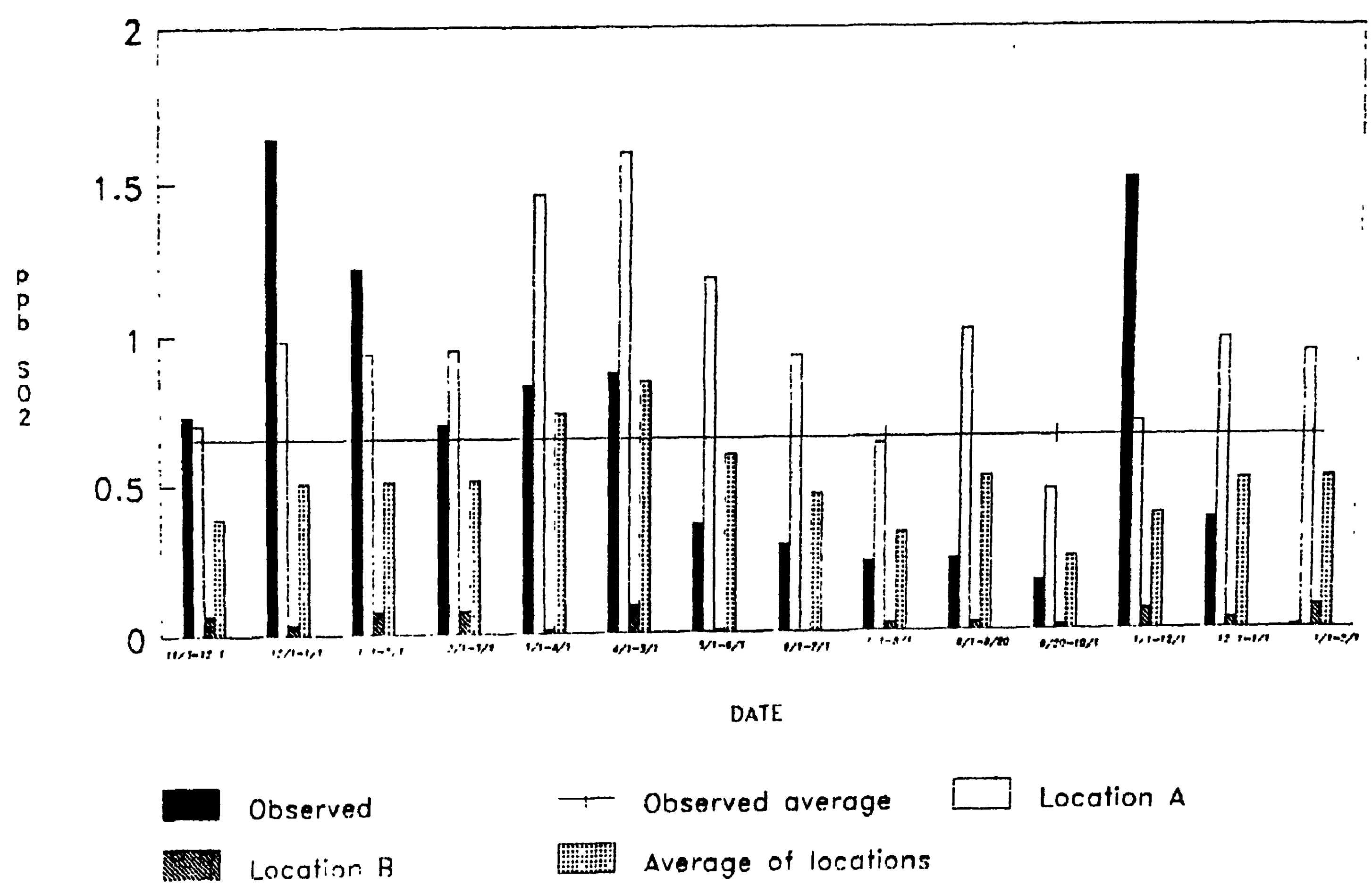
AVERAGE SO_2 CONCENTRATION FROM PASSIVE DIFFUSION SAMPLERS AT VARIOUS STATIONS IN INDIA.

STATION	µg/m3
BERHAMPUR	1.18
VARANASI	2.75
BOMBAY	11.15
COCHIN	1.71
DELHI(CPCB)	34.26
DELHI(IIT)	21.71
JAIPUR	5.98
KASHEELE	3.62
MADRAS	5.51
NEHU	1.33
AGRA	6.1

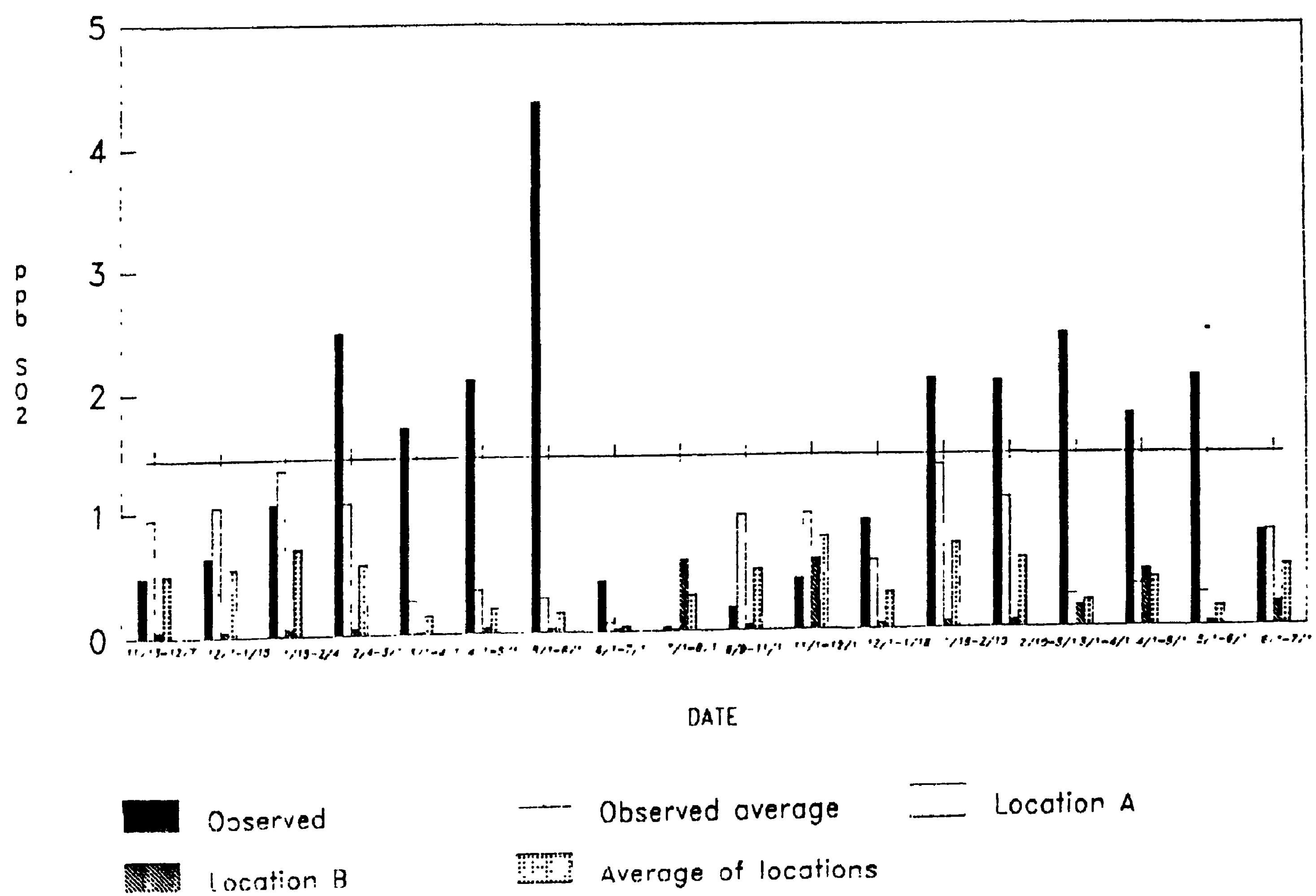
OBSERVED AND PREDICTED CONCENTRATION OF SO2 AT BOMBAY IIT



OBSERVED AND PREDICTED CONCENTRATION OF SO2 AT COCHIN



OBSERVED AND PREDICTED CONCENTRATION OF SO2 AT KASHEELE



Dr B. Mukhopadhyay, IMD

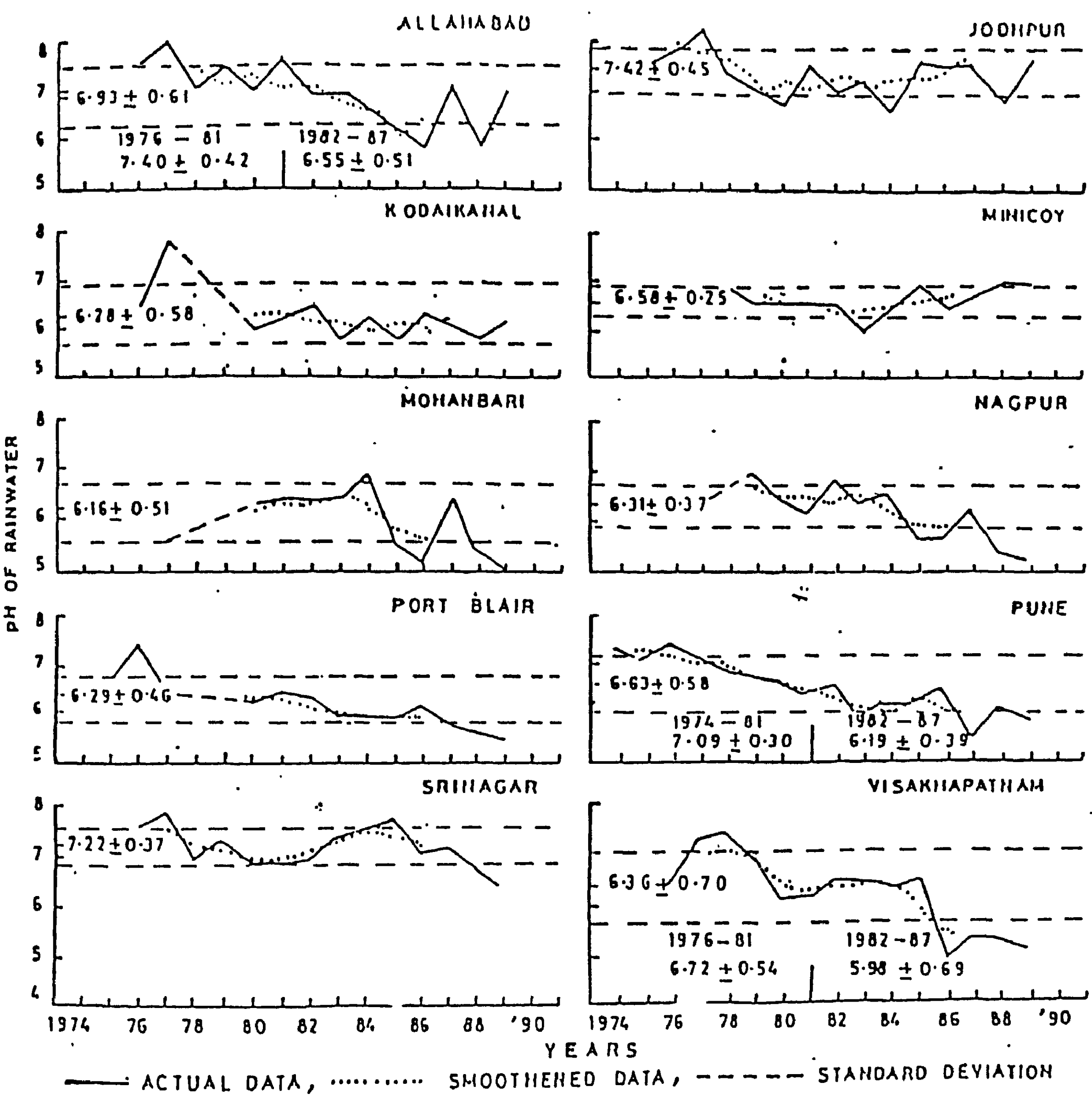
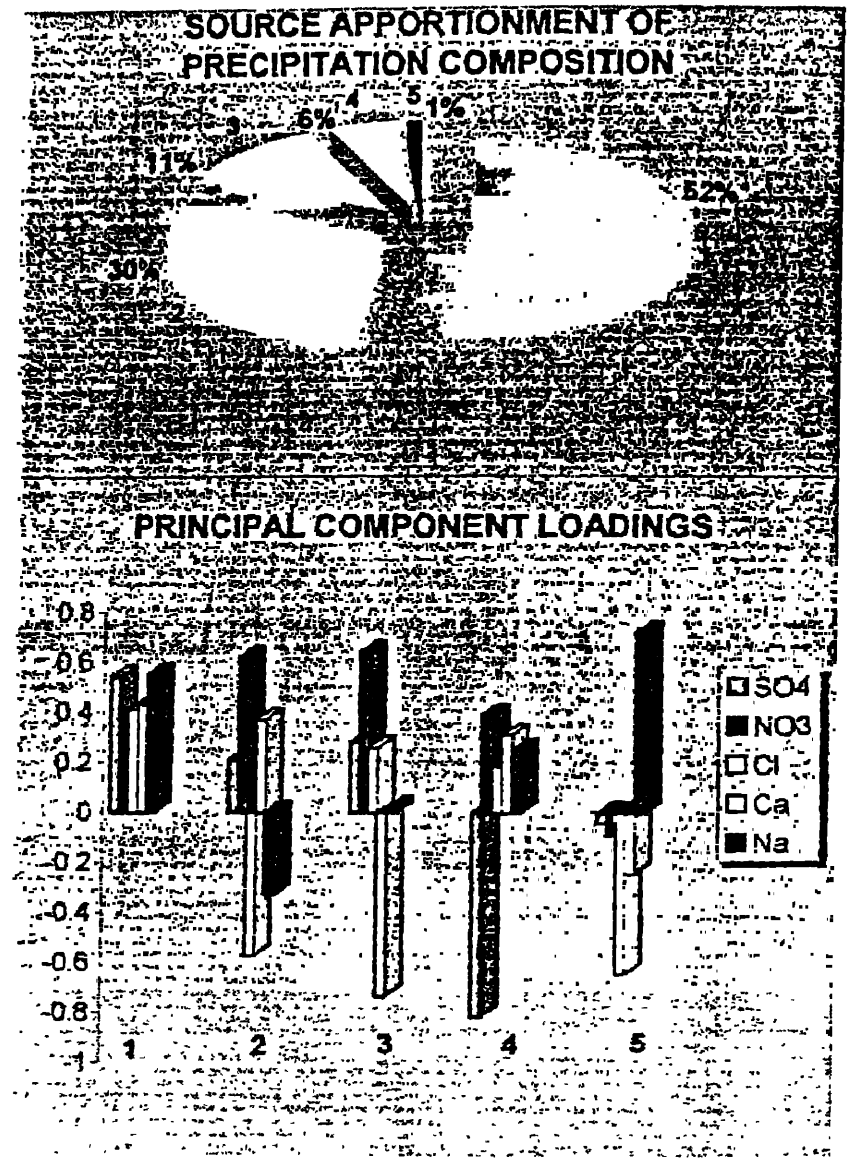
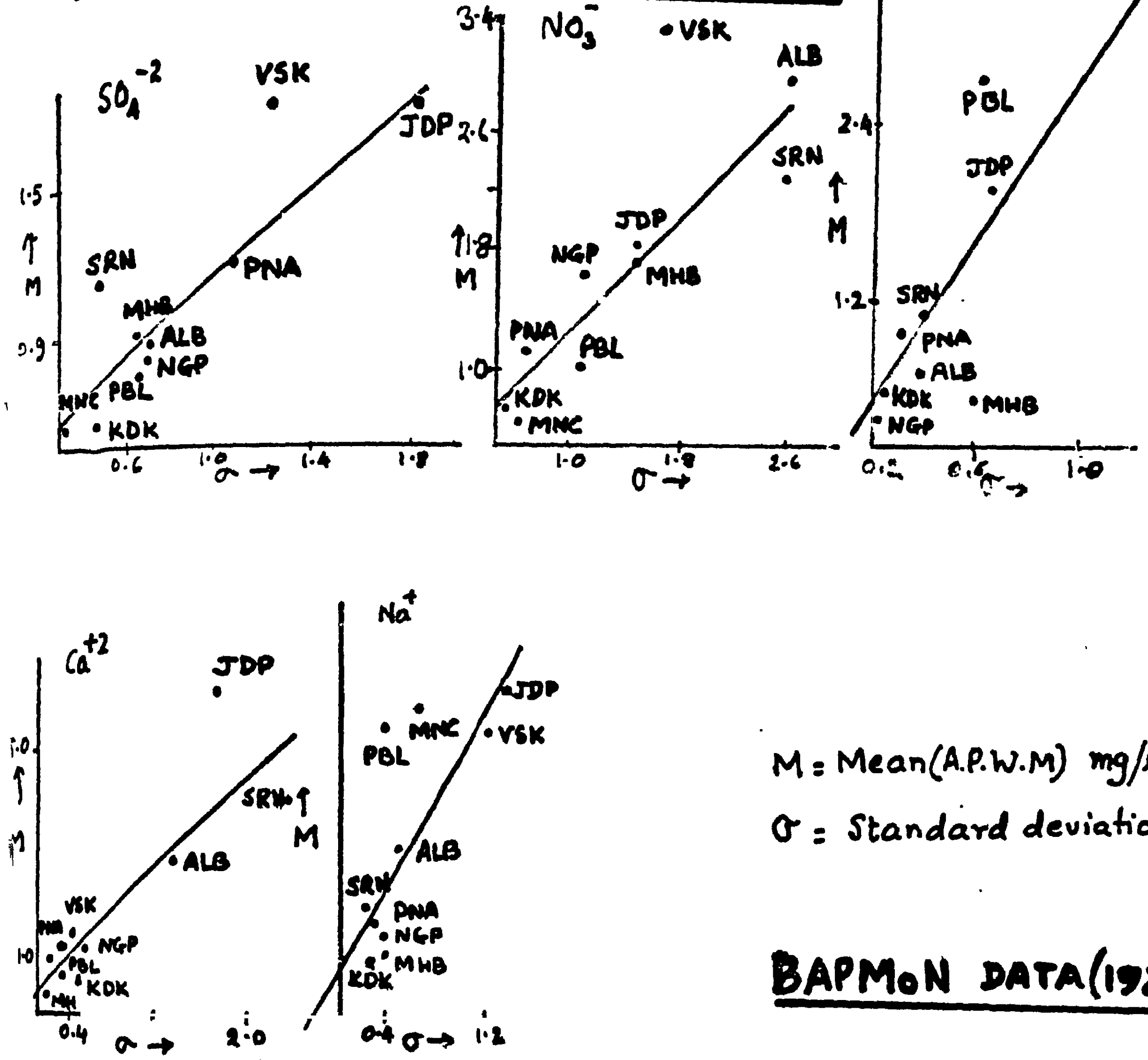


Fig. 3. Annual pH of rainwater in Indian DAPMoN stations


SOURCE APPORTIONMENT OF PRECIPITATION COMPOSITION
3
4
5
6%
1%
11%
52%
30%
PRINCIPAL COMPONENT LOADINGS
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
1
2
3
4
5
SO4
NO3
Cl
Ca
Na

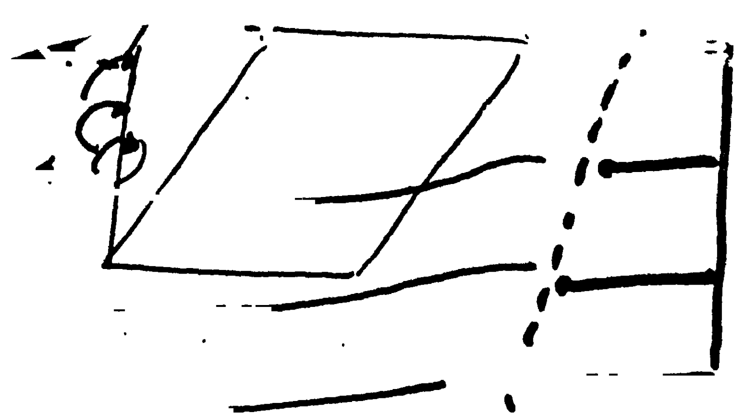
Relative abundance of ionic constituents.



M = Mean(A.P.W.M) mg/Lit.

σ = Standard deviation.

BAPMoN DATA(1976-87)

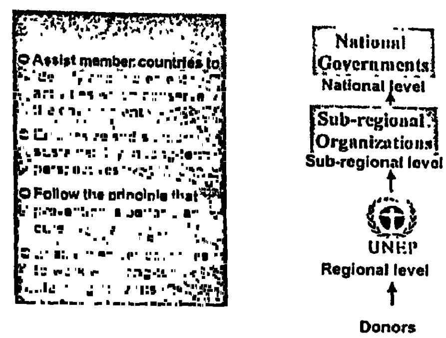


MR. SUNIL MALLA, UNEP

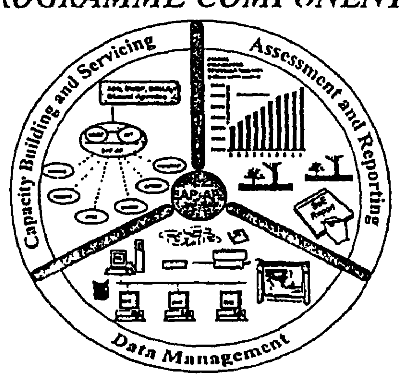
UNEP
ENVIRONMENT ASSESSMENT PROGRAMME
Asia and the Pacific

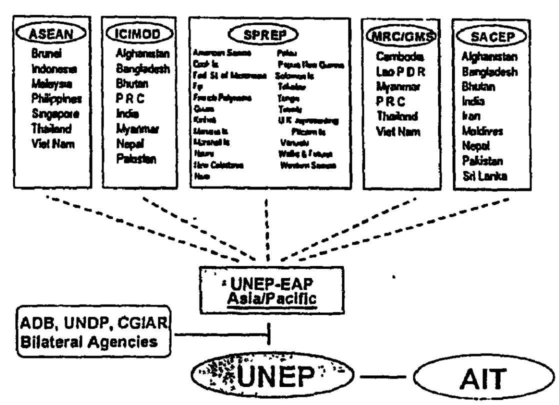
- ◎ *EAP-AP*
- ◎ *AIR POLLUTION ISSUES*
- ◎ *ACID RAIN PHASE II PROJECT*

MISSION



PROGRAMME COMPONENTS





Environment Assessment Programme: 1993-97

Assessment and Reporting.

★ Consultation: South Asia (Oct. & Nov. '94), Mekong (Feb. '95 & 96), SPREP (Feb. '95, Mar. '96), ASEAN (Jul., Sep. '95 & Jun '96)

★ Land Cover: Cambodia, Bangladesh, Laos, Malaysia, Myanmar Nepal, Thailand, Viet Nam

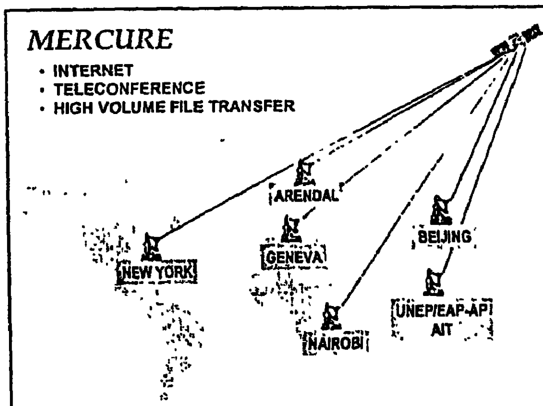
☆ ESCAP SoE Report: SoE Data Base

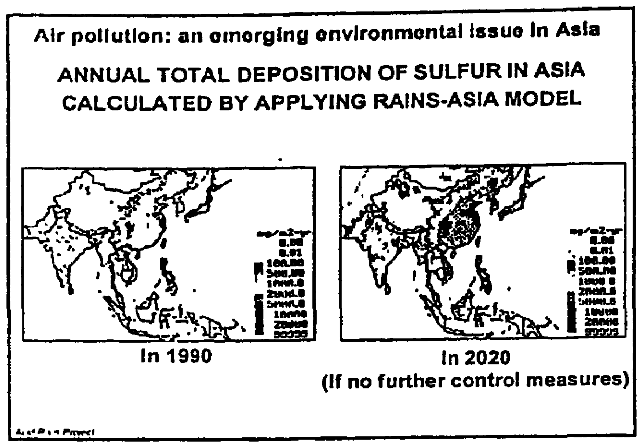
★ Conducted Sub-regional consultations for GEO

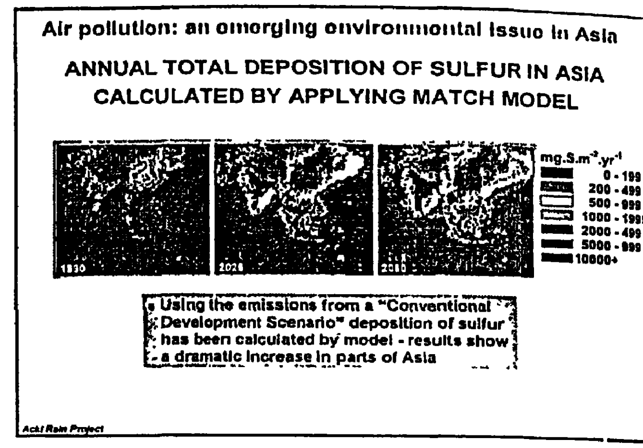
★ Completed GEO Regional Consultation Report

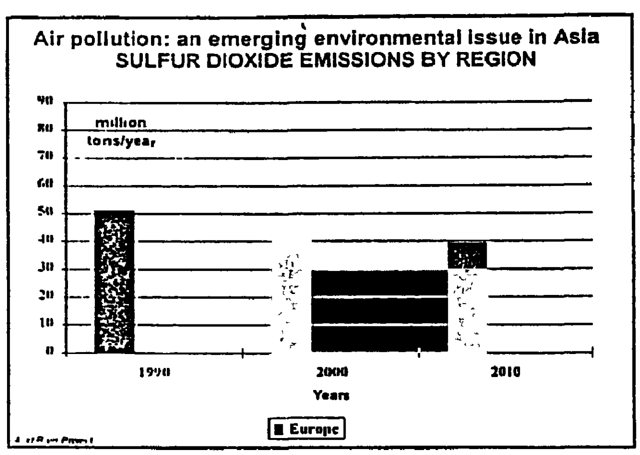
MERCURE

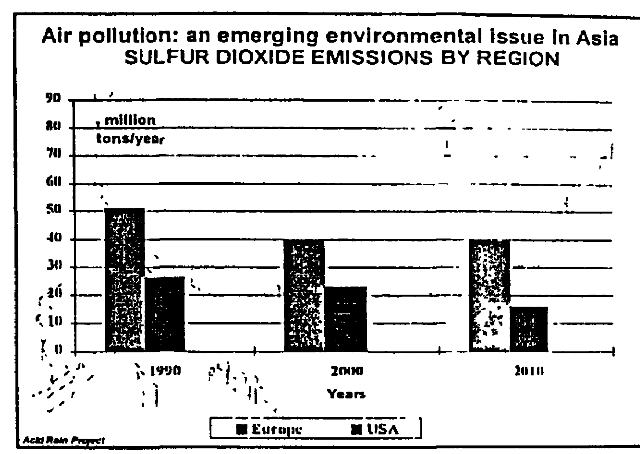
- INTERNET
- TELECONFERENCE
- HIGH VOLUME FILE TRANSFER

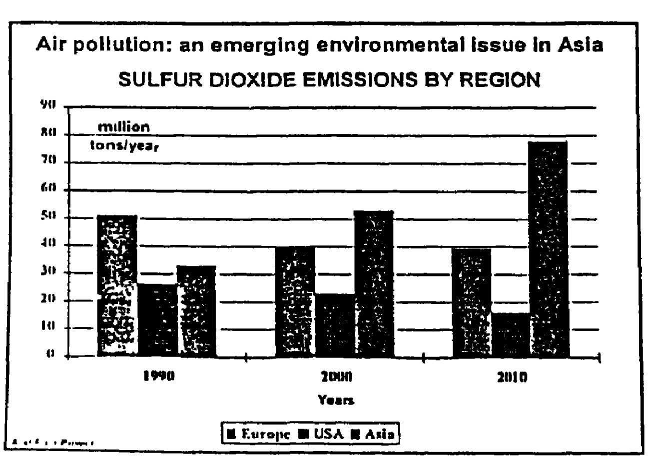



Air pollution: an emerging environmental issue in Asia
ANNUAL TOTAL DEPOSITION OF SULFUR IN ASIA
CALCULATED BY APPLYING RAINS-ASIA MODEL
In 1990
In 2020
(If no further control measures)


Air pollution: an emerging environmental issue in Asia
ANNUAL TOTAL DEPOSITION OF SULFUR IN ASIA
CALCULATED BY APPLYING MATCH MODEL
mg.S.m-2.yr-1
0 - 199
200 - 499
500 - 999
1000 - 1999
2000 - 4999
5000 - 9999
10000+
Using the emissions from a "Conventional Development Scenario" deposition of sulfur has been calculated by model - results show a dramatic increase in parts of Asia
Acid Rain Project


Air pollution: an emerging environmental issue in Asia
SULFUR DIOXIDE EMISSIONS BY REGION
million
tons/year
1990
2000
2010
Years
Europe


Air pollution: an emerging environmental issue in Asia
SULFUR DIOXIDE EMISSIONS BY REGION
million
tons/year
1990
2000
2010
Years
Europe
USA
Acid Rain Project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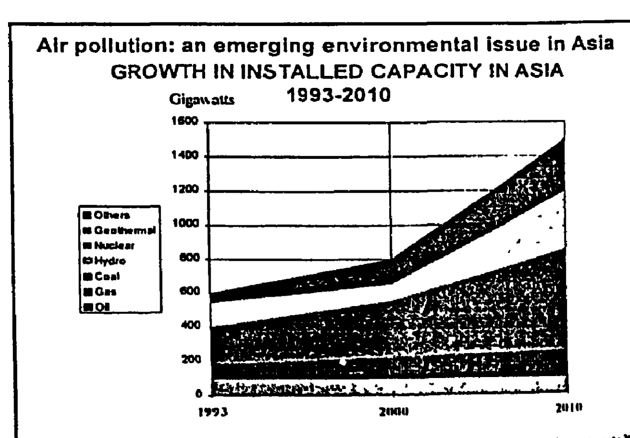
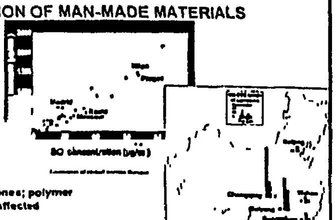

Air pollution: an emerging environmental issue in Asia
GROWTH IN INSTALLED CAPACITY IN ASIA
Gigawatts
1993-2010
Others
Geothermal
Nuclear
Hydro
Coal
Gas
Oil
1993
2000
2010
Acid Rain Project

Air pollution: an emerging environmental issue in Asia

EFFECTS: CORROSION OF MAN-MADE MATERIALS

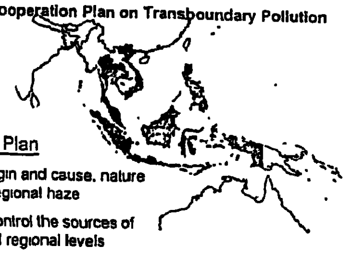


- Metals; painted surfaces, calcareous stones; polymer materials, electronics and buildings are affected
- Caused by acid deposition (from sulfur and nitrogen) and ozone
- Large economic implications - $9000 million savings per year in Europe by reducing sulfur to protocol levels from 1990 emissions
- In Asia, high humidity, temperature and precipitation increase risk of corrosion damage by pollutants

Sub-regional Status: Southeast Asia

Major Initiatives:

1. Agreed: Air pollution is a priority issue in the region
2. Formulated: ASEAN Cooperation Plan on Transboundary Pollution



ASEAN Cooperation Plan

- to assess the origin and cause, nature and extent of local and regional haze
- to prevent and control the sources of haze at both national and regional levels
- to develop and implement national and regional emergency response plans

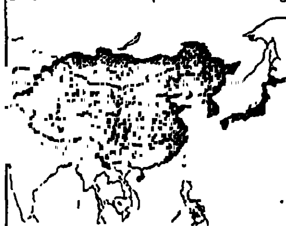
Acid Rain Project

Sub-regional Status: Northeast Asia

Major Initiatives

1 Agreed Air pollution is a priority issue in the region

2 Formulated Acid deposition monitoring Network



Acid deposition monitoring Network

- establishment of national acid deposition monitoring networks
- establishment of a monitoring network center in the region
- exchange of data, experience and information
- central compilation and analysis of monitoring data
- pursuit of capacity building activities

Acid Rain Project

Sub-regional Status: South Asia

Major Initiatives:

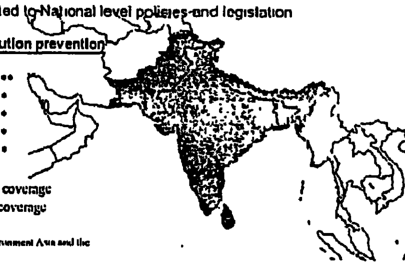
1. Agreed: Male' Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia
2. Formulated Limited to National level policies and legislation

Status of air pollution prevention legislation

Bangladesh	••
India	•
Nepal	•
Pakistan	•
Sri Lanka	•

Key •• Moderate coverage
• Minimal coverage

Source: State of the Environment Asia and the Pacific (ESCAP 1990)



Acid Rain Project

ACID RAIN & EMISSIONS REDUCTION IN ASIA, Phase II

History

Institutional genesis 1989 (AIT) [illegible]

Phase I [illegible] World Bank funded [illegible] 1994 [illegible]

Outcomes: • Database [illegible] SO_2 Monitoring • RAINS-Asia [illegible]

Future Direction: • Modification • Local expertise [illegible] Cooperation [illegible]

Phase II • [illegible] (ADB) • Sep 97, Apr 99 • US$ [illegible]

Objectives • [illegible] • Capacity Building • Regional Cooperation [illegible]

Activities • Database • Seminar/workshop, information dissemination [illegible]

Other on going parallel projects [illegible]
• World Bank II • Japan (ADMNEA) • SEI/Sida (Air Pollution)

UNEP

ACID RAIN & EMISSIONS REDUCTION IN ASIA PHASE II

MAIN OBJECTIVE:

- To utilize the computer model developed under the phase I in the development of policies & programs to reduce ARCEs...

IMPLEMENTATION:

- Establishment of Acid Rain Coordinating Center
- Database of key Acid Rain experts
- Energy/emission and socio-economic database
- Evaluation of policies and technologies to reduce ARCEs
- Regional workshops/training
- National workshops/training

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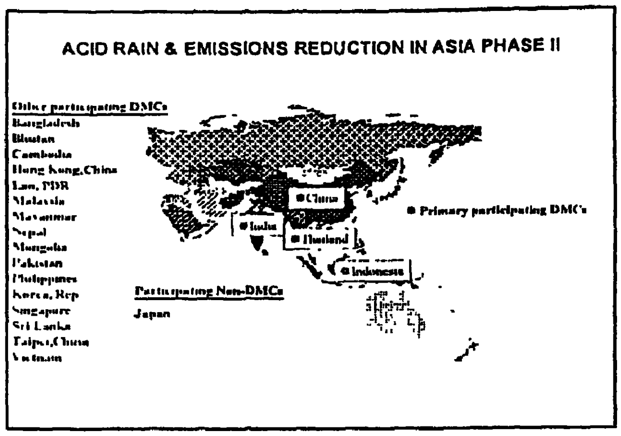
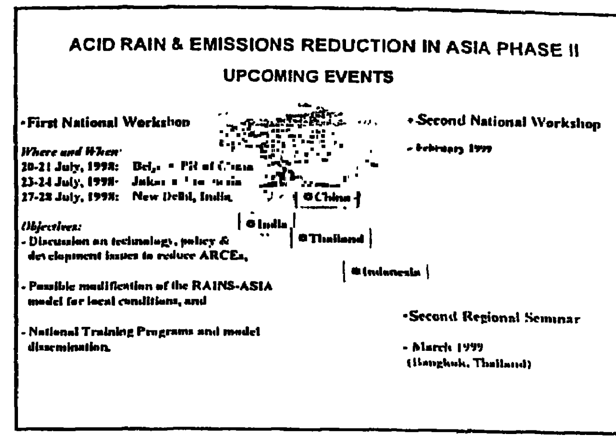
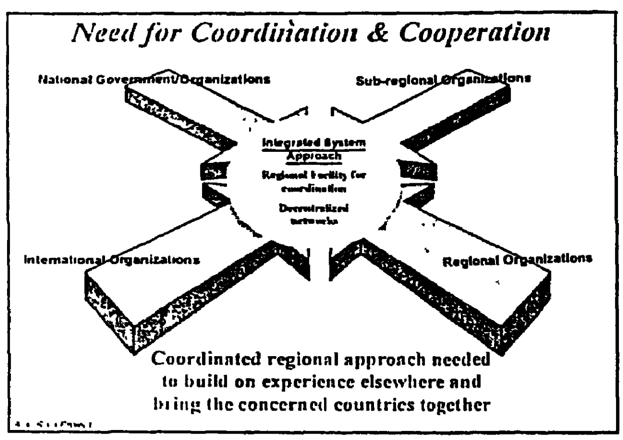
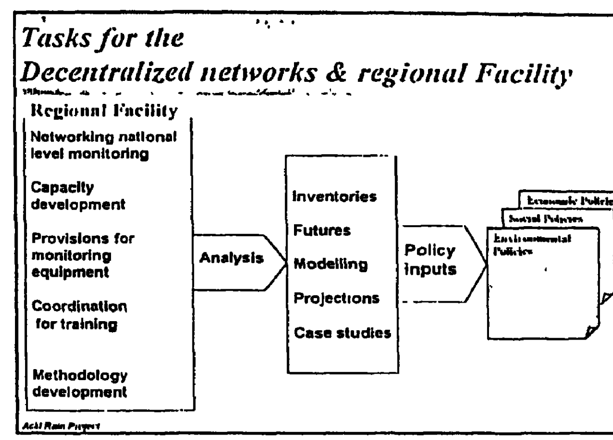
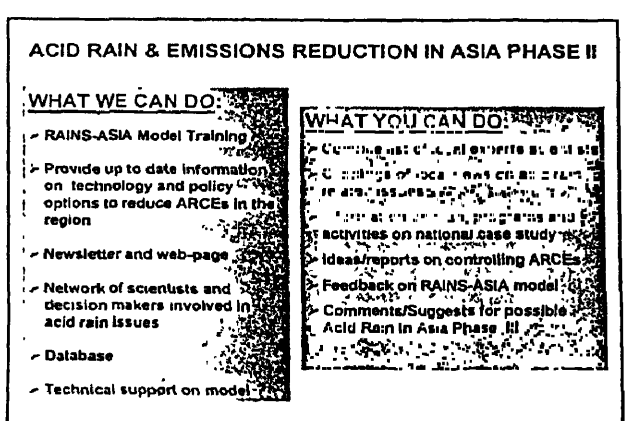
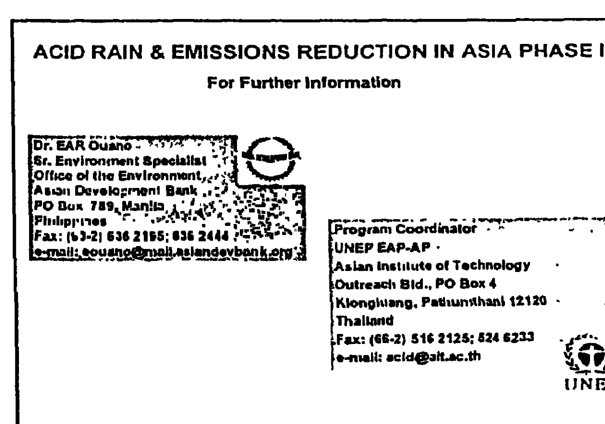

ACID RAIN & EMISSIONS REDUCTION IN ASIA PHASE II
Other participating DMCs
Bangladesh
Bhutan
Cambodia
Hong Kong,China
Lao, PDR
Malaysia
Myanmar
Nepal
Mongolia
Pakistan
Philippines
Korea, Rep
Singapore
Sri Lanka
Taipei,China
Vietnam
China
India
Thailand
Indonesia
Primary participating DMCs
Participating Non-DMCs
Japan


ACID RAIN & EMISSIONS REDUCTION IN ASIA PHASE II
UPCOMING EVENTS
•First National Workshop
Where and When:
20-21 July, 1998:
23-24 July, 1998:
27-28 July, 1998: New Delhi, India
Objectives:
- Discussion on technology, policy & development issues to reduce ARCEs,
- Possible modification of the RAINS-ASIA model for local conditions, and
- National Training Programs and model dissemination.
China
India
Thailand
Indonesia
•Second National Workshop
- February 1999
•Second Regional Seminar
- March 1999
(Bangkok, Thailand)


Need for Coordination & Cooperation
National Government/Organizations
Sub-regional Organizations
Integrated System Approach
Regional Facility for coordination
Decentralized networks
International Organizations
Regional Organizations
Coordinated regional approach needed
to build on experience elsewhere and
bring the concerned countries together


Tasks for the
Decentralized networks & regional Facility
Regional Facility
Networking national level monitoring
Capacity development
Provisions for monitoring equipment
Coordination for training
Methodology development
Analysis
Inventories
Futures
Modelling
Projections
Case studies
Policy inputs
Economic Policies
Social Policies
Environmental Policies
Acid Rain Project


ACID RAIN & EMISSIONS REDUCTION IN ASIA PHASE II
WHAT WE CAN DO:
- RAINS-ASIA Model Training
- Provide up to date information on technology and policy options to reduce ARCEs in the region
- Newsletter and web-page
- Network of scientists and decision makers involved in acid rain issues
- Database
- Technical support on model
WHAT YOU CAN DO:
activities on national case study
Ideas/reports on controlling ARCEs
Feedback on RAINS-ASIA model
Comments/Suggests for possible Acid Rain in Asia Phase III


ACID RAIN & EMISSIONS REDUCTION IN ASIA PHASE II
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e-mail: acid@ait.ac.th
UNEP

Collaboration with Sida/SEI on Air pollution

POLICY DIALOGUE ON REGIONAL AIR POLLUTION ISSUES

9-20 March, 1998

Participants

Target countries for the phase.I (South Asia)

- Bangladesh
- India
- Nepal
- Pakistan
- Sri Lanka
- ADB, ASEAN,SACEP
- AIT, ERTC
- Sida, SEI, UNEP

Main Aims

- Create a broader dialogue of the air pollution issues in Asia
- Promote the policy cycle in South Asia by:

(I) re-affirmation that transboundry air pollution is a priority issue for South Asia;

(ii) agreeing upon a draft action plan for inter-governmental activities at the policy dialogue.

UNEP SEI STOCKHOLM ENVIRONMENT INSTITUTE Sida

Collaboration with Sida/SEI on Air pollution

MALE' DECLARATION

SACEP GC MEETING

Held on 22 April 1998 in Male, Maldives.

Inaugurated by His Excellency Mr. Maumoon Abdul Gayoom, President of Maldives

Attended by ministers and high level policy makers from South Asian Environment ministries.

Major Initiative

Male' declaration on control and prevention of air pollution and its likely transboundary effects for South Asia was agreed as a results of policy dialogue

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Collaboration with Sida/SEI on Air pollution

IMPLEMENTATION OF THE MALE' DECLARATION

A MoU between SEI and UNEP/EAP-AP was signed on May'98 to covert the Male' Declaration into action

Tasks

- Ensure that each government appoints a national focal point
- Prepare and provide generic guideline and terms of reference for the national focal points to prepare the baseline studies and action plans
- Provide technical support to the national focal points
- Ensure acceptable quality control on baseline studies and action plans

UNEP SEI Sida

Press Release on "*Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia*".

In a meeting of SACEP (South Asia Cooperative Environment Programme) held in Malé (Maldives) on 22 April 98, all South Asian Governments have approved a Declaration on Control and Prevention of Air Pollution. This declaration is the end result of a process started on the joint initiation of UNEP/EAP-AP based at Asian Institute of Technology, Bangkok and the Stockholm Environment Institute. On 20 March 1998, representatives of South Asian Governments, including India, Pakistan, Bangladesh, Nepal, Sri Lanka, Bhutan and Maldives met for a policy dialogue meeting held at the Asian Institute of Technology (AIT), Bangkok, Thailand and agreed in principle to a draft South Asian Declaration on Control and Prevention of Air Pollution. The policy dialogue meeting was organized by the United Nations Environment Programme/Environment Assessment Programme for Asia and Pacific (UNEP/EAP-AP) based at AIT, and the Stockholm Environment Institute (SEI) based in Stockholm, Sweden as part of the Regional Air Pollution Program in Developing Countries, funded by the Swedish International Development Co-operation (Sida) and managed by SEI.

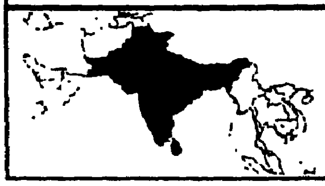
The draft declaration was put before the South Asian environmental ministers for the official declaration at the Seventh meeting of the Governing Council of South Asia Cooperative Environment Programme (SACEP) held on 22 April 1998 in Malé, the Republic of Maldives. The Governing Council meeting was inaugurated by His Excellency Mr. Maumoon Abdul Gayoom, President of the Republic of Maldives and attended by ministers and high level policy makers from South Asian environment ministries. It resulted in the approval of the Declaration on control and prevention of air pollution by South Asian Governments.

The **aim of the Declaration** is to achieve intergovernmental cooperation to address the increasing threat of transboundary air pollution and consequential impacts due to concentrations of pollutant gases and acid deposition on human health, ecosystem function and corrosion of materials. Besides laying down the general principles of intergovernmental cooperation for air pollution abatement, the Declaration sets up an institutional framework linking scientific research and policy formulation. The Declaration also calls for the continuation of this process in stages, with mutual consultation, to draw up and implement national and regional action plans and protocols based on a fuller understanding of transboundary air pollution issues.

As a result of the Declaration the **major implications in the short-term** could be: (I) evolving of an institutional structure at national level both for of policy response and the technical requirements; (ii) strengthening of monitoring arrangements; (iii) baseline studies to assess and analyze the air pollution issue; and (iv) **development and/or adoption of national action plans**.

In the **long-term**, the Declaration could be one of the **central means for protecting the atmospheric environment in South Asia**. In the years to come it could serve as one more bridge between different political systems and as a factor of some stability in years of political change. It could lead to the development of international environmental law and also create the essential framework for controlling and reducing the damage to human health and the environment caused by localized and transboundary air pollution. It is a successful example of what can be achieved through intergovernmental cooperation.

In addition to the Declaration, a **follow up action plan** has also been agreed. Follow up activities will be implemented in three levels, National, Sub-regional and Regional. In addition to the baseline studies and national action plans, a network of researchers and policy makers will also be established at the national level. At the sub-regional level, national level activities will be aggregated through SACEP. Dissemination of tools, methodologies, and data will be done at the regional level through a regional resource center. The follow up program will be implemented by UNEP/EAP-AP in collaboration with SEI and SACEP and with Sida support.



Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia

Recognizing the potential for increase in air pollution and consequential phenomena due to concentration of pollutant gases, acid rain or acid deposition as well as the impacts on the health of humans and other living organisms in all our countries due to man made and natural causes; and also

Recognizing the potential for increase in transboundary air pollution as a corollary of air pollution in each country; and

Realising that the potential for air pollution increase and its transboundary effects will accumulate in the absence of national measures to abate and prevent such potential; and

Reiterating in this context Principle 21 of the UN declaration on the Human Environment in 1972 which stated that States have, in accordance with the charter of the United Nations and the principle of international laws, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction;

Keeping in mind that need for constant study and monitoring of the trends in air pollution with a view to understand the extent of our potential for damage to the environment and health in the member countries and taking consequential measures to strengthen and build capacity for such activities;

Stressing the need for development and economic growth that will help build up the quality of life and incomes of all the people of all the region, in particular the poorer sections of the population, having due regard to the need to have a clean and healthy environment;

Emphasizing that air pollution issues have to be analyzed and managed in the wider framework of human and sustainable development within each country and within the region; and

Drawing from the experience of co-operation in the region in matters like cultural exchange and also from the experience in other regions like Europe and sub-regions of Asia like ASEAN and East Asia.

We declare that countries of this region will initiate and/or carry forward programmes in each country to

1. Assess and analyze the origin and causes, nature, extent and effects of local and regional air pollution, using the in-house in identified institutions, universities, colleges etc., building up or enhancing capacities in them where required;
2. Develop and/or adopt strategies to prevent and minimize air pollution;
3. *Work in co-operation with each other to set up monitoring arrangements beginning with the study of sulfur and nitrogen and volatile organic compounds emissions, concentrations and deposition;*
4. Co-operate in building up standardised methodologies to monitor phenomena like acid depositions and analyse their impacts without prejudice to the national activities in such fields;
5. Take up the aforesaid programmes and training programmes which involves then transfer of financial resources and technology and work towards securing incremental assistance from bilateral and multilateral sources:
6. Encourage economic analysis that will help arriving at optimal results
7. Engage other key stakeholders for example industry, academic institutions, NGOs, communities and media etc. in the effort and activities.

We also declare that we shall constantly endeavor to improve national reporting systems and strengthen scientific and academic effort in the understanding and tackling of air pollution issues.

We further declare that we shall continue this process in stages with mutual consultation to draw up and implement national and regional action plans and protocols based on a fuller understanding of transboundary air pollution issues.

We declare that in pursuit of the above, we shall evolve, as appropriate, institutional structures at the national level, including networking, ~~both for the~~ purposes of policy and the technical requirements, and we shall use the good offices of regional, international ~~bilateral and~~ multilateral agencies in this, as appropriate.